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NEXT MEETING: The American Society of Ichthyologists and Herpetologists will meet on the campus of Indiana University, Bloomington, Indiana, from Aug. 24 to Aug. 28, 1958, inclusive. The sessions will be held in conjunction with the meetings of the American Institute of Biological Sciences.

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Morphometry and Ecology of Small Tarpon, *Megalops atlantica*  
 Valenciennes from Transitional Stage Through  
 Onset of Scale Formation<sup>1</sup>

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ROBERT W. HARRINGTON, JR.

THE enigmatic early life of the tarpon, *Megalops atlantica* Valenciennes is an intriguing problem in relative growth. A presumed leptocephalus stage with subsequent shrinking and transformation implies maximal allometric growth, yet so precocious is the onset of isometric growth that the lineaments of a 350-pound adult are discernible in an inch-long juvenile. Bound up with growth is the question of the origin and developmental pattern of the enormous scales, which reach a diameter of two inches. Finally, there remains the secret of the habitat and adaptive features of the undiscovered stages.

The synoptic study of Breder (1944) incorporated in its critical analyses all relevant data of previous contributions to the biology of the tarpon. A large gap remains, however, between Breder's putative preleptocephalid larva, which died after three days' development, and his smallest post-larval specimen, 42 mm. standard length. This gap widened with the loss of the latter, so that his measurements began with a specimen 52 mm. long. Simpson (1954) has since recorded with customary counts and measurements a specimen of 37 mm. standard length. Hildebrand (1934) described a tarpon 20 mm. in total length judged to be in transition from the leptocephalus stage, which latter remains to be discovered for this species, although known for its eastern relative, *Megalops cyprinoides* (Broussonet) for some time (Van Kampen, 1909). Hildebrand's specimen was lost before an illustration was made. Because of its unexpected fin ray count Breder (1944) judiciously accorded it the status of a probable record until such time as additional material might clarify this count.

The writer and his co-workers collected in 1956 a graded series of 259 tarpon (Table I) from 16.0 mm. standard length (18.8 mm. total length) up to the sizes of the smallest post-larval tarpon measured by Breder. This series complements Breder's, extending our

knowledge down to the leptocephalus stage, and validates the isolated record of Hildebrand. They were collected between September 10 and October 10 along Indian River, Florida incidental to a study of the movements and food preferences of larvivorous fishes during the autumn inundation of salt marshes and the annual peak of saltmarsh mosquito hatching. Further environmental details will be given with the comprehensive study. A prior analysis of the present material was enforced by the necessity of sacrificing most of it later in the over-all dietary study.

The writer is especially indebted to Mr. William L. Bidlingmayer and Mr. James S. Haeger, who resourcefully implemented his field plans under conditions of extreme discomfort during the greater part of a month when the author was absent. He is grateful to Dr. Erik Tetens Nielsen for the mathematical formulation of the weight-length relationship, to Mr. Willem Janse for rendering most of the drawings, and to Mr. William Wood for photography. Finally he wishes to acknowledge the benefits to the concluding ecological discussion afforded by conversations with Dr. Maurice W. Provost.

ENVIRONMENTAL CONDITIONS AND  
 COLLECTING DATA

An unusually prolonged drought preceded the autumn inundation along the banks of Indian River in 1956. Daily observations made in August and in early September throughout the marsh witnessed the drying up of pond after pond, leaving but three, each reduced to a few yards in extent and a few inches in depth. The only surviving fish were a few small individuals of *Cyprinodon v. variegatus* (Lacépède) restricted to the three contracted expanses of water, in which temperatures reached 48°C. and specific gravities, 1.0410 (after correction to 15°C.). Tidal waters remained below marsh level until September 9, when almost 5½ inches of rain fell within a few hours. The entire marsh area was abruptly flooded to eight inches above

<sup>1</sup>Contribution No. 49, Entomological Research Center, Florida State Board of Health, Vero Beach, Florida.

its previously dry ground surface by the combined high tide and heavy rain. From September 9 into October, when observations were ended, all ponds were brim full, and water was usually two to 19 inches deep over the marsh except for two days when ebb tide brought it to marsh ground level in places. Data were provided routinely by tide gauges and a recording rain gauge installed during the drought period. A continuous sheet of water was commonly present across as much

of vertical-slit traps, in two of four poisonings with rotenone, and in 23 of 24 seinings. They were obtained on nine of 16 collecting days, and with effective seining could doubtless have been taken on any day throughout the postdiluvial period. They were commonly found in temporary ponds at the hammock line engulfed by the farthest incursion of the flood waters, in larger, more permanent ponds, in potholes in the open marsh, and in a sump dug at the hammock line. Without doubt they were ubiquitous in the marsh. Water temperatures at collection times ranged as follows, maximum 28-32°C., mean 27-32°C., minimum 24-30°C. Surface salinities ranged 14-45 ppt, but were transitory, and even such round numbers are misleading because of stratification, circulation, dilution, and leaching from the salt-encrusted bottom, not to mention fish movement.

Twenty-seven collections contained tarpon. Fifteen other species taken concurrently in the marsh appeared in the tarpon collections with the following frequencies: *Gambusia affinis holbrooki* Girard, 23; *Mollienesia latipinna* LeSueur, 23; *Mugil curema* Valenciennes, 22; *Cyprinodon variegatus* *variegatus* (Lacépède), 17; *Centropomus undecimalis* (Bloch) young of the year, 16; *Elops saurus* Linnaeus, leptocephali and post-leptocephalic stages, 11; *Lucania parva* (Baird and Girard), 8; *Fundulus grandis grandis* Baird and Girard, 5; *Fundulus confluentus confluentus* Goode and Bean, 4; *Eugerres plumieri* (Cuvier), 3; *Evorthodus lyricus* (Girard), 1; *Fundulus similis* (Baird and Girard), 0; *Rivulus marmoratus* Poey, 0; *Menidia beryllina* (Cope), 0; *Dormitator maculatus* (Bloch), 0.

Breder (1944: 229 and Table VI) from two samples of his smallest tarpon—one taken while the tarpon were entering a pool landlocked soon afterwards, the other later from the same pool—infers a mean growth of 2 cm. in 12 days. From this he calculated a mean growth rate representing a 616.2 percent increase in total length per year. Mean standard lengths of our collections made successively during a month show no trend, and the two smallest individuals were taken a month after the marsh was first flooded (Table I) both of which facts are consistent with a continuing influx of tarpon from Indian River. If the outsized lengths relegated to the bottom of Table I and possibly belonging to a different growth stanza be ignored, maximum lengths show a consistent increase, but a growth rate based on such maxima would be unreliable.

TABLE I  
LENGTH FREQUENCY DISTRIBUTION OF YOUNG  
*Megalops atlantica* TAKEN IN A SALT MARSH,  
INDIAN RIVER COUNTY, FLORIDA, SEPTEMBER  
10 TO OCTOBER 10, 1956

Standard Length in mm.	September			October	
	10-12	17-18	28	1-3	10
16-17.9	5	3	1	2	2
18-19.9	5	4		4	1
20-21.9	13	2	3	3	1
22-23.9	6	2	15	5	2
24-25.9	2	1	21	7	7
26-27.9	3	1	15	6	2
28-29.9	2	6	8	11	1
30-31.9	1	5	4	5	3
32-33.9		8	3	1	1
34-35.9		1	3	1	1
36-37.9		4	1	2	5
38-39.9		1			6
40-41.9		1	1	1	3
43-44.9			2		4
45-46.9			1		1
47-48.9				1	1
49-50.9				1	3
52-53.9				1	1

Omitted from table: 5 (56 mm., 57 mm., 65 mm., 71 mm., 73 mm.) Sept. 17-18; 3 (59 mm., 79 mm., 83 mm.) Sept. 28; 1 (109 mm.) Oct. 1.

as 400 yards of formerly parched salt marsh, so that the whole marsh up to the hammock line was co-extensive with the open waters of Indian River on most days from September 9 to after mid-October. The inescapable fact emerges that tarpon first entered the marsh from Indian River on September 9, and were able freely thereafter to enter or leave throughout and beyond the interval during which collections were made. The study area was a typical *Batis-Salicornia* marsh with the usual aggregations of black mangrove, *Avicennia nitida* Jacquin bordering ponds, in sloughs, and along the hammock line.

Tarpon were taken in three of 89 settings

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### METHODOLOGY OF MEASUREMENTS AND CONVERSIONS

Body measurements were made to one-tenth of a millimeter, with vernier calipers. Each fish was weighed separately to the nearest two milligrams, on a Roller-Smith balance. Specimens were fixed in 10 percent formalin, washed in water, and preserved in 70 percent ethyl alcohol. Before being measured, they were returned to water; afterward they were blotted with filter paper to remove surface moisture and rapidly weighed. All measurements made by Breder (1944) were taken, those not explicitly defined by him being made in the manner prescribed by Hubbs and Lagler (1947). Total length as defined by Breder (1944) was taken but is not recorded here. Total length refers to the measurement as defined by Hubbs and Lagler (1947), the measurement Breder (1944) called overall length.

Fork lengths and total lengths were plotted against standard length. These points sub-scribed graphically to linear regressions expressed by the function,  $y = a + bx$ , in which  $x$  = standard length, and  $y$  = fork length or total length, as the case may be. Various estimates of  $a$  were obtained algebraically by substituting different couples of paired empirical coordinates in simultaneous equations, and also by fitting a line by eye to the plotted data. When  $y$  equaled fork length, estimates of  $a$  fell about -1; when  $y$  equaled total length, they fell about -2, so that these two convenient values were adopted for  $a$ . In either case, the value of  $b$  was then computed by substituting a pair of coordinates determining a point cut by the line passing through the appropriate value of  $a$  and fitted by inspection to the series of empirical dots. Thus were the following conversion formulae obtained:

$$F.L. = 1.1282 \times S.L. - 1.$$

$$T.L. = 1.3333 \times S.L. - 2.$$

Conversions obtained by slide rule with the above formulae fitted well throughout the range of lengths specified above, with the qualification that below 25 mm. standard length, empirical total lengths consistently fell slightly below computed total lengths. This might be ascribed to either or both the more pronounced allometry in smaller fish and increased difficulty in appressing their caudal lobes while manipulating calipers.

### BODY PROPORTIONS

Proportional measurements were made on 160 fish selected from those enumerated in Table I so as to represent the full range of standard lengths. Measurements converted to percentages in thousandths of standard length are shown graphically in Figure 1 in order of descending degree of allometry regardless of whether it be positive or negative. The differential (heterogonic) growth of body parts and regions clearly reveals a transitional period, presumably from a leptocephalus stage. This phenomenon of *incrementum in-egale*, to use the older, more explicit terminology (D'Arcy Thompson, 1952: 184, footnote), is extreme at 16-19 mm. standard length and still considerable to about 35-40 mm., when it gradually resolves itself into what is essentially *incrementum in universum*. The precise point at which allometry yields to isometry is not obvious, and if the latter is not complete, it is no less so than in Breder's 164 specimens, which ranged from 50 mm. to 2030 mm. in standard length, and in which growth was deemed only slightly heterogonic (Breder, 1944).

Comparable percentages from Breder (1944, Table III) for body proportions, averaged at 50-60 mm. standard length and (in parentheses) at variable standard length frequencies between 610 mm. and 2030 mm., are arranged below in the order followed in Figure 1: Dorsal origin, 54.0 (51.0); pelvic length, 17.2 (11.1); head, 31.3 (23.3); anal height, 20.0 (15.0); dorsal height, 22.2 (16.1); upper jaw, 18.6 (12.4); pectoral length, 19.9 (15.7); depth, 25.0 (23.1); pectoral insertion, 30.9 (28.8); anal origin, 70.9 (68.4); last dorsal ray, 10.3 (19.9); anal base, 20.2 (18.6); pelvic insertion, 52.2 (42.0); snout, 6.9 (4.5); orbit, 7.6 (3.6); dorsal base, 10.2 (9.4); interorbital width, 5.5 (4.6).

Comparison of these data with Figure 1 shows that the low level of differential growth of body components noted by Breder conforms with that starting at between 35 mm. and 40 mm. standard length, as recorded by the empirical dots of Figure 1. It will be noted from Breder's data i.e., by comparing the figure in parentheses with the one preceding it, that all the above proportions show appreciable if slight negative allometry except for the last dorsal ray, which, as Breder has pointed out, is conspicuous for its positive allometry. This recalls the fact that except for those proportions virtually isometric from

the start only the distances from snout to dorsal and anal origins showed negative allometry within the range of standard lengths in the Indian River series up to 35-40 mm. Thus in the earliest growth the majority of

the obvious body proportions show extreme positive allometry with reference to standard length, all these proportions then becoming isometric at about 35-40 mm. standard length, and thereafter all but one of them

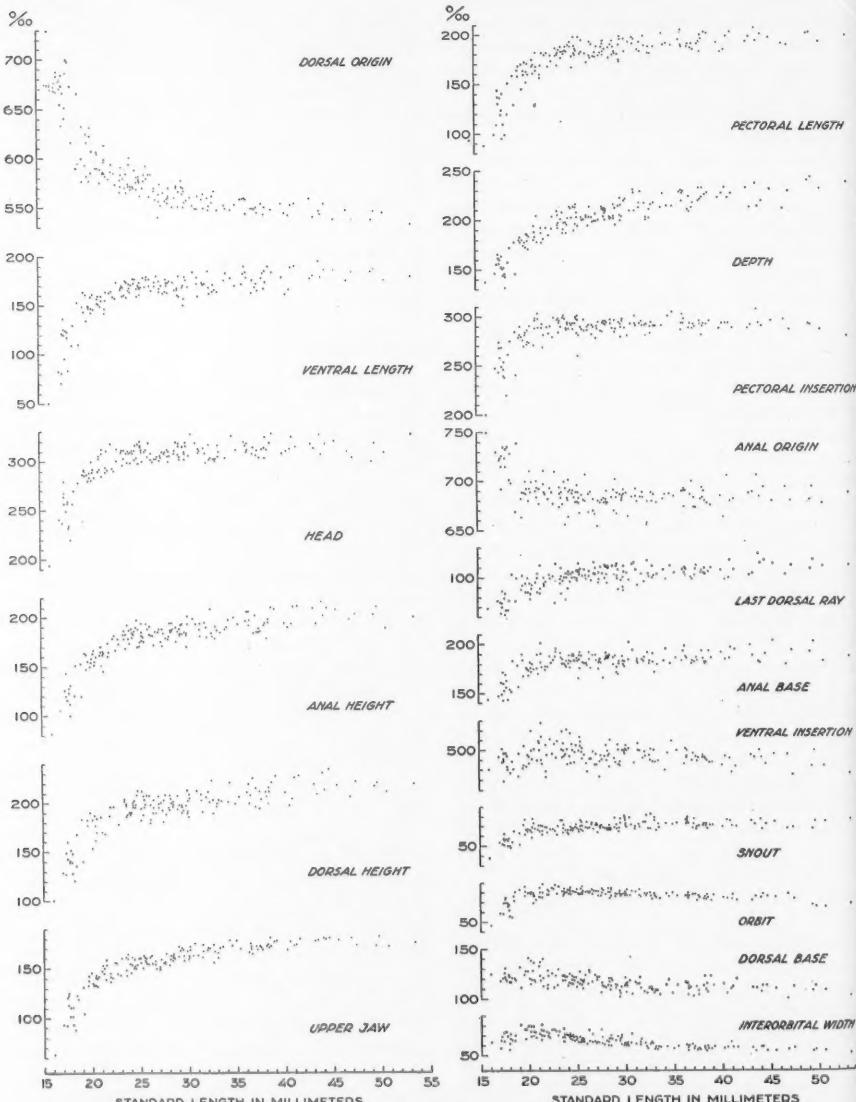


Fig. 1. Scatter diagrams of measurements on 160 tarpon, 16.0-53.5 mm. standard length (18.8-69.0 mm. total length), in thousandths of standard length, arranged in order of degree of allometry. Ventral (of Breder, 1944) = pelvic.



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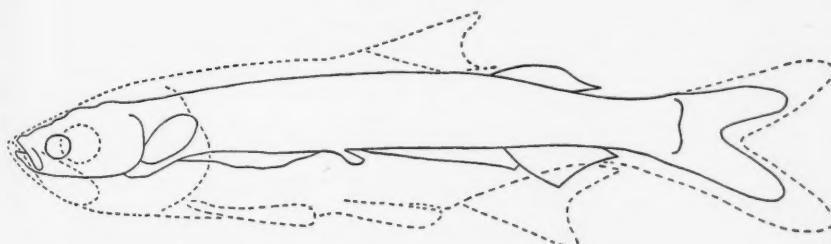


Fig. 2. Profiles of a tarpon 36.8 mm. standard length (broken lines) and an early transitional stage 16.0 mm. standard length (solid lines) superposed and altered in size so their standard length dimensions coincide.

showing slight but unmistakable negative allometry. The precise isometric point with reference to standard length and its developmental significance is not obvious.

A synoptic apprehension of the nature and extent of proportional changes up to near this point is afforded by Figure 2, in which the outline of a specimen 36.8 mm. in standard length (the largest fish shown in Pl. II) is superposed on that of our smallest specimen (16 mm. in standard length), with the two so adjusted in size that their standard length dimensions coincide. In the larger specimen, a single scale row had recently formed and a second row was just appearing. Figure 5 and Plates I and II give a better idea of the appearances of these two stages and of other significant length stages represented in figure 1 than would a detailed verbal description.

#### THE RELATION OF WEIGHT TO LENGTH

In Figure 3, empirical weights to the nearest two milligrams are plotted against empirical standard lengths to the nearest tenth of a millimeter. The same data plotted on logarithmic coordinates does not approximate a straight line. When it was apparent that weight was increasing at a much greater rate than is encompassed by the so-called cube law,  $W = cL^3$ , Dr. E. T. Nielsen suggested that the weight-length relationship might possibly subscribe to the function

$$W = a + b \cdot c^L \quad (1)$$

in which  $W$  is the weight,  $L$ , the length, and  $a$ ,  $b$ , and  $c$ , are constants. The function becomes linear by the following manipulation  $(W - a) = b \cdot c^L$

$$\log (W - a) = \log b + L \log c \quad (2)$$

The constants were calculated by Dr. Nielsen from three estimated averages of  $W$  corre-

sponding with three values of  $L$  equidistant from one another. After substitution of these constants, (2) becomes

$$\log (W + 150) = 1.74145 - 0.029045 \times L$$

and (1) becomes

$$W = -150 + 55.14 \times 1.069^L$$

In accordance with the logarithmic form of the equation, the logarithm of the sum of each weight + 150 was plotted against the

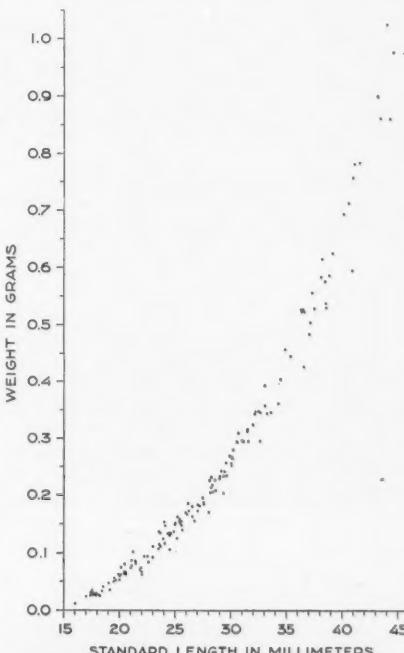


Fig. 3. Empirical weight-length relationship, its curve conforming to the equation, Weight =  $-150 + 55.14 \times (1.069)^{\text{Length}}$ . Data from 154 tarpon, 16.0-45.5 mm. standard length.

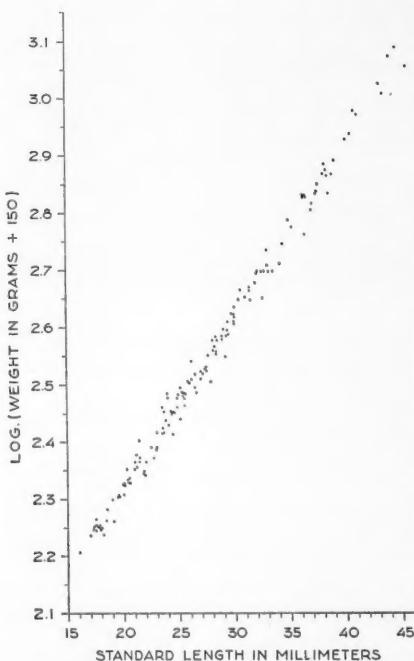


Fig. 4. Weight-length data plotted on semi-logarithmic coordinates, in accordance with the logarithmic form of the equation of Figure 3.

corresponding standard length. Figure 4 attests the appropriateness of the function and the accuracy of the constants computed from the empirical data. The magnitude of the rate of weight increase per increment of length may be partly visualized from the profiles of Figure 2, but is better apprehended from the calculation that if continued in accordance with the above function and constants, a tarpon 100 cm. long would weigh  $6 \times 10^{21}$  metric tons! In the legend of Figure 3, the number and standard lengths of the fishes weighed are noted. Additional specimens of larger size were measured, and there is reason to suspect that the growth stanza

within which the above weight-length relationship holds ends at about 45 mm. standard length, but the additional measurements were too few to constitute more than an indication.

#### MERISTIC COUNTS AND THE SMALLEST POST-LEPTOCEPHALUS TARPON

Breder (1944) was dubious about the tarpon 20 mm. in total length reported by Hildebrand (1934) chiefly because it had dorsal and anal counts of 12 and 20, respectively. These are counts commonly given for adults, although Breder found that smaller specimens had much larger counts, reduced later by consolidation of the foremost elements. He observed that if taxonomists had had access to smaller specimens, the customary counts would most likely have included all the rays, as was done only by Fowler (1936), who used lower case Roman numerals for the abortive anterior rays, and by Breder, who made no distinctions among the rays counted. With this in view, counts were made on dorsal, anal, and caudal rays of 162 tarpon, over the range in lengths indicated in Table II. The caudal ray count (19) may be dismissed since it was virtually constant from the smallest to the largest fish of the series, serving merely to recall that the caudal fin was well differentiated in the smallest specimen whereas the other fins were not. Table II should remove any doubts of the validity of Hildebrand's record on the score of fin ray count, and fulfills the prediction of Breder that its validation would imply first an increase in the count followed by reduction through consolidation.

Hildebrand's professed acquaintance with leptocephali and later stages of *Elops* and *Albula* (Hildebrand, 1934) undoubtedly sharpened his eye for the details of young *Megalops*, and his description fits our specimen (Fig. 5 and Pl. I) although it is somewhat smaller than his (18.8 mm. versus 20 mm. total length). It should be mentioned that the dorsal and anal rays of our specimen

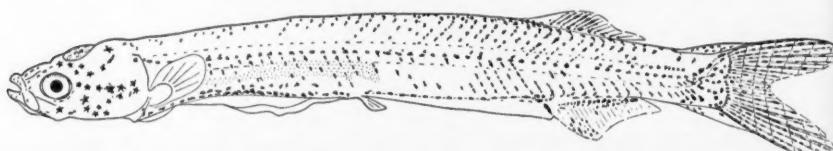


Fig. 5. The smallest recorded post-larval tarpon, *Megalops atlantica* Valenciennes, a transitional stage, 16.0 mm. standard length (18.8 mm. total length). Compare photograph of same in Plate I.

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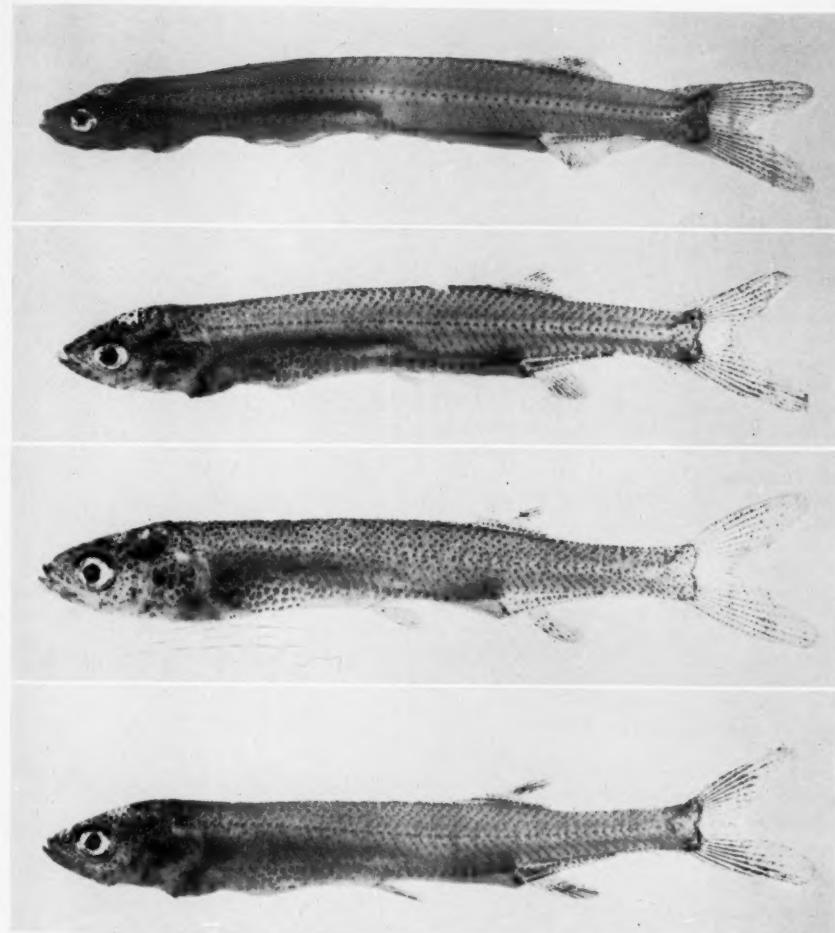


Plate I. Young tarpon, *Megalops atlantica* Valenciennes enlarged to about the same size. Standard lengths followed in parentheses by total lengths, top to bottom: 16.0 mm. (18.8 mm.), 17.2 mm. (20.0 mm.), 17.5 mm. (21.0 mm.), 19.6 mm. (23.0 mm.).

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consisted merely of bars of different refractive index from the matrix from which they were emerging. A summation of the frequencies of total ray counts and of the frequencies of jointed ray counts will be found at the bottom of Table II, the latter approaching the frequencies of the conventional adult counts. A hazard in counting the abortive, unjointed rays in smaller specimens is that often the two lateral, mirror-image components of some of these incipient rays are not yet fused and through inadvertency may be

the larval state. Behind the pelvic girdle, which changes its relative position so little during development (Fig. 2), the alimentary tract has retained that appearance so common in larval fishes, of a tube appended to the ventral border. A striking deviation from the leptocephalus shape as found in *Elops* is the slight body depth; and although the body is laterally compressed it is not greatly so in proportion to the depth. Hildebrand's specimen, at least in preservative, was devoid of color whereas ours is distinctly pigmented (Fig. 5 and Pl. I).

TABLE II  
FIN RAY COUNTS ON 162 *Megalops atlantica* IN RELATION TO  
EARLY STAGES OF GROWTH

Standard Length in mm.	Dorsal Rays								Anal Rays							
	12	13	14	15	16	17	18	20	21	22	23	24	25	26	27	28
16.0	1							1								
17-18.9		6	7					6	7	1						
19-20.9		3	9	2					1	9	2	2				
21-22.9		2	8	5					1	6	5	3				
23-24.9		2	6	7	2				2	2	9	4				
25-26.9		1	5	10					1	1	8	5	1			
27-28.9		1	2	13	1					6	9	2				
29-30.9			5	8	1					5	7	2				
31-32.9			1	7	2					1	5	4				
33-34.9			2	3	2					1	4	2				
35-36.9				1	5						3	2	1			
37-38.9				2	8	1				1	4	5	1			
39-40.9				1	3							4				
41-43.9					2	2						3	1			
44-45.9					2	2					2	1		1		
46-47.9					1	1						1	1			
49-50.9					3							1	2			
53-59.9					1	1	1					2	1			
Totals	1	1	15	47	69	26	3	1	6	12	19	38	50	30	4	2
Totals Jointed Rays Only	28	116	18					10	64	69	16	3				

counted separately thus giving a higher than warranted count.

Hildebrand mentioned the clarity with which myomeres and vertebrae show up, as is the case with our specimen, and, of course, with leptocephali in general. The alimentary canal (Fig. 5 and Pl. I) is far more differentiated than in any *Elops* leptocephali examined by the present writer, having evaginated a dorsally pigmented air bladder of considerable size. The ample early development of this respiratory organ which stands young tarpon in such good stead (see Breder, 1944) and so strikingly influences their behavior (Schlaifer and Breder, 1940) is noteworthy with regard to a presumptive change in environments upon transformation from

#### SCALE FORMATION

In reflected light under magnification the earliest sign of lepidogenesis was a series of flat depressions along the lateral line formed in relation to the neuromasts. These depressions appear first from opposite the dorsal base to the middle of the caudal peduncle, later extending rapidly forward and more slowly backward. This condition prevailed from its earliest inception at about 30.0 mm. standard length through 33.0-33.9 mm. and may just barely be seen in the specimen 33.0 mm. in standard length in Plate II. The depressions next became transformed into raised oval plateaus so incisive under oblique illumination as to appear embossed. The plateaus started differentiating at about 30.0 mm., though mostly not before 32.0 mm., but variability was such that in one fish 35.5 mm. long the antecedent flat depressions were only just forming. Such plateaus persisted at the growing ends of incomplete rows, and appeared at the origins of newly forming rows.

In Table III, no distinction is made among depressions, plateaus and later phases of scale differentiation. Each number in parentheses is an average of counts of any and all such phases. These averages give the approximate extent of each incipient row at time of origin and a rough measure of progress toward completion, but no indication of the locus of the series of components in each row at its first appearance nor of the directions in which subsequent increments are added. Such data were given above for the lateral-line row, which with allowance for some irregularity (see Table III) was the primary row. The evidence was unequivocal that all five rows paralleling the lateral line row below originated at their definitive anterior ends, extending caudad with the addition of successive increments or groups of increments. As a consequence, the customary count of

scale rows below the lateral line is misleading until these rows reach their full extent. The oval plateaus were the earliest scale primordia seen in these five rows, but antecedent depressions can not be ruled out as they are visible only under optimal oblique lighting and might be effaced by swelling, shrinking or wrinkling of body regions less firm than the lateral line region. Observation of scale row formation above the lateral line is hampered

Table III, and needs no further exposition. In the lowermost specimen (36.8 mm. in standard length) of Plate II, scales are in formation throughout the lateral line row and at the anterior end of the first row below.

The technique of Neave (1943) for studying scale pattern development, so effectively adapted by Everhart (1949) for determining priority of scale development along rows by counting the number of circuli per scale, was

TABLE III  
ONSET AND PROGRESS OF SCALE FORMATION IN TARPON WITH REFERENCE  
TO SCALE ROW AND STANDARD LENGTH

Standard Length in mm.	Numbers of Fish	Numbers Totally Unscaled	Numbers of Fish with Forming or Formed Scales per Scale Row <sup>1</sup>									
			Scale Rows (lateral line row, 0; rows above, +; below, -)									
			+4	+3	+2	+1	0	-1	-2	-3	-4	-5
16-29.9	101	101										
30-30.9	7	5					2(22)	1(5)				
31-31.9	5	2					3(21)					
32-32.9	5	1					4(35)	3(12)				
33-33.9	4						4(32)	4(16)				
34-35.9	4						4(39)	4(18)	1(4)			
36-36.9	5						4(21)	5(41)	5(34)	5(10)		
37-37.9	5							5(39)	5(21)	5(9)		
38-38.9	6						4(35)	6(38)	6(34)	5(15)	3(9)	
39-40.9	4						2(13)	4(36)	4(40)	4(29)	3(16)	2(9)
41-41.9	2						1(?)	2(41)	2(42)	2(38)	2(25)	2(14)
43-43.9	2						2(?)	2(38)	2(40)	2(38)	2(23)	2(14)
44-44.9	3			1(?)	3	3	3(40)	3(37)	3(29)	3(22)	3(7)	1(6)
45-46.9	2				1	2	2(42)	2(38)	2(28)	2(26)	1(11)	
47-50.9	4				4	4	4(42)	4	4	4	4	
53-57.9	2				2	2	2(43)	2	2	2	2	2(?)
59.6	1				1	1	1(44)	1	1	1	1	1
Totals	162	109					53					

<sup>1</sup> Number of fish followed in parentheses by the average number of scales per row. Question mark indicates uncounted incomplete row of scales. Apparently complete rows not counted except for lateral line row.

by heavier pigmentation and by the apparently simultaneous formation of a larger number of components at the outset of these rows. Although these rows first appeared somewhat tardily, they seemed to be completed more swiftly, and resemble the lateral-line row not only in the larger number of components present at the outset but in materializing first from opposite the dorsal base to the middle of the caudal peduncle, then growing forward and backward. The order in which the entire scale rows originated and approached completion is apparent from

not used here as it would have entailed the premature mutilation of a unique series of specimens. At best in the present case, moreover, it could only have refined the above description with supplementary quantitative detail. Under reflected light accurate counts of circuli are not feasible, but at 34.0-35.9 mm., circuli were undeniably present in scales of the lateral line from opposite the dorsal base to the middle of the caudal peduncle, extending forward in one case beyond the midpoint of the lateral line. In one fish examined, the first few scales of the row below

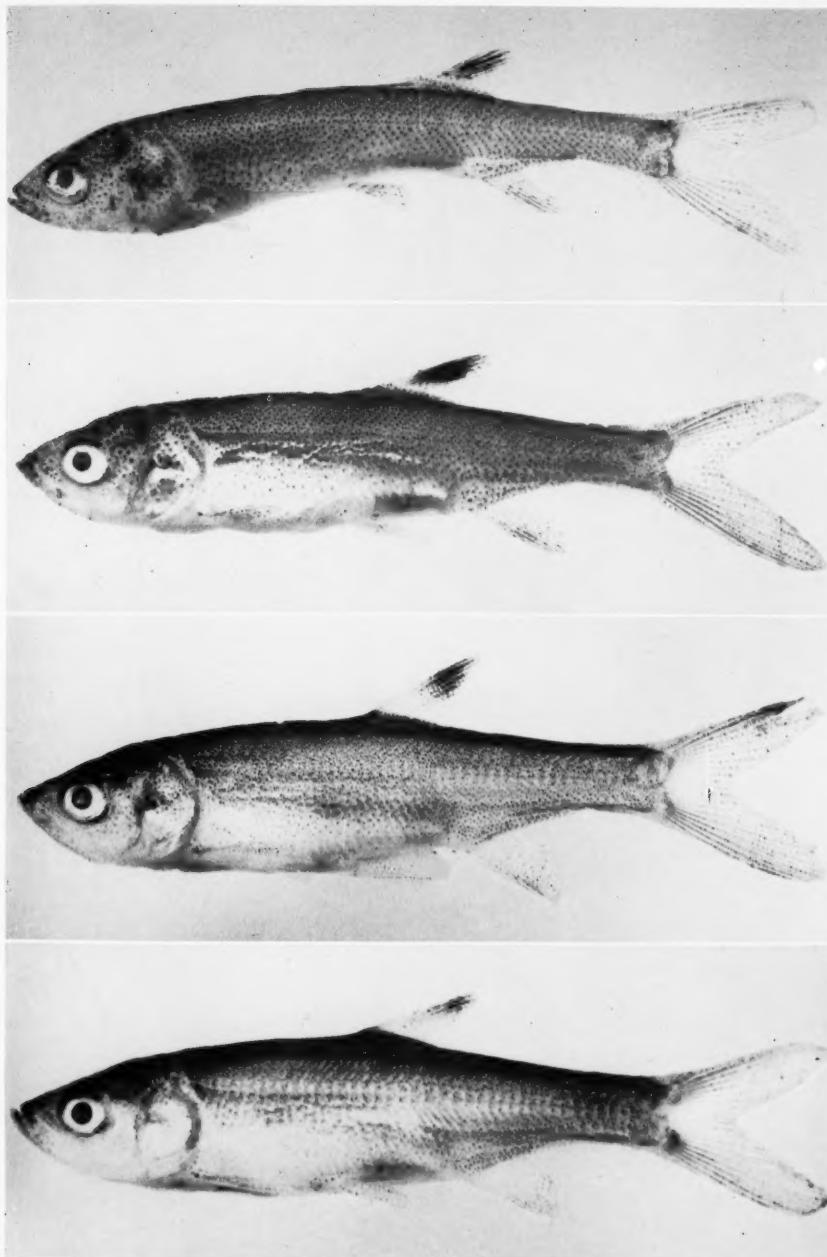


Plate II. Young tarpon, *Megalops atlantica* Valenciennes enlarged to the same size. Standard lengths followed in parentheses by total lengths, top to bottom: 20.1 mm. (24.3 mm.), 25.5 mm. (31.5 mm.), 33.0 mm. (41.0 mm.), 36.8 mm. (46.0 mm.).

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also had several circuli. In some fish of this size range all scales of the lateral line row exhibited the overlap leading to imbrication. At 38 mm. several circuli per scale were found throughout the lateral-line row, on some scales of the row above, of the first two rows beneath, and in one case, of the third row beneath. Scale overlap was now widespread.

In sum, the earliest visible sign of scale formation occurred at 30 mm. standard length, some circuli were formed at least at 34.0 mm., if not at slightly lesser lengths. The lateral-line row is the first to develop, starting from opposite the dorsal base to the middle of the caudal peduncle, with rapid forward and slow backward extension. The rows above originate in the same region with forward extension later, but the first row above the lateral line appears later than the first row beneath, roughly coincident with the advent of the second and third rows beneath. In contrast with the points of origin of the lateral-line row and those above it, the origination at their definitive anterior ends of all rows beneath, with subsequent incremental growth caudad, is noteworthy. Prior formation of the lateral-line row with the focus of development posterior is in line with the course of scale development in other isoppondylous fishes as is a standard length at onset of scale formation of 30-34 mm., whatever criterion of onset is invoked (compare summaries of Everhart, 1949 and Van Oosten, 1957).

#### DISCUSSION

The present series makes the Florida east coast and Indian River in particular pre-eminent among such places as Sanibel Island and Boca Grande, Florida, Aransas Pass, Texas, and the West Indies as a source of minimal sized post-larval tarpon, and enhances the significance of the solitary specimen in post-larval transition found by Hildebrand at Beaufort, N. C. The observed predilection of tarpon for spawning in shallow, inshore waters among islands suggests the possibility of such activity among the islands and near the inlets of Indian River as an alternative to long distance dispersal of leptocephali by ocean currents. The provisional assumption (Breder, 1944) that tarpon with one check mark on their scales have passed but one winter, implies that all specimens described here were far less than a year old, especially since only the largest had a full complement of scales. In conjunction with an asserted spawning period during

May, June, and July, it argues a duration of up to one to four months for the combined pre-leptocephalid and leptocephalus stages. The alternative is a wintering over of the leptocephalus, adding at least a year of precarious life as a fugitive from predatory crustacea (see Breder, 1944 concerning planktonic predators) but time for extensive dispersal. Despite the obvious example of the eel, there would seem to be some grounds for suspecting that the smallest Indian River specimens were not more than a few months from the egg, and that in Indian River the autumn inundation may prove a turning point in the early ecology of tarpon.

The massive proportional changes and terrific increase in weight per increment of length noted above, as well as the accelerated growth rate inferred by Breder (see above), would seem to imply an equally tremendous food intake. The transitional stage concerned is perhaps initiated by abrupt environmental change or by the passing of a critical size so as both to free the small fish from former crustacean enemies and to potentiate its exploitation of a different category of food, or by the action of one of these hypothetical factors upon the other. The ecological adjustments of the leptocephalus and its antecedents remain unknown, but at least the minimal post-larval requirements for survival and growth have now become accessible to study. In this connection, it may be noted that an analysis of the changing diet will form part of the comprehensive study to which the present paper is incidental. When data become available, a synopsis of all growth stanzas of the tarpon from hatchling to full sized adult with attention not only to length, weight, and proportional changes but to their correlation with developmental episodes and ecological crises would be of great theoretical interest.

Indian River conditions prompt a tentative qualification of the dictum of Breder (1944) that post-storm, land-locked tarpon represent peripheral wastage and not the effective individuals of the tarpon stock i.e. if this be construed to include all such tarpon as venture inland with rising waters. Insular, essentially non-tidal swales and sloughs such as those on Sanibel Island cited by Breder are not the ecological equivalents of Indian River salt marshes. On Sanibel Island, for instance, a head of rain water builds up in the swale or slough behind the beach barrier, then breaks through it, forming a transitory connection with the ocean. Soon afterward,

ocean wave action seals up the gap so formed, reimpounding the waters behind the barrier, which then gradually dry up. Breder does not explicitly include in his zone of peripheral wastage the bay side mangrove swamps and salt marshes of the San Carlos Bay region, which are more nearly the ecological counterparts of the Indian River marshes. It is here that, by analogy with Indian River conditions, one might sooner expect to encounter biologically effective elements of the tarpon stock entering with the invading waters and later retreating with them, as do so many other fishes. While not denying the specific validity of Breder's dictum, perhaps a distinction should be made between the periphery of open waters and of lagoons as such.

With this in view, attention is drawn on to the fact, so important to salt-marsh mosquito ecology, that spring tides high enough to inundate the marshes occur in May, June, and July on the Gulf coast (coincident with the asserted spawning period of tarpon), but not until August, September, and October on the Atlantic coast of Florida. Although marsh inundation is thus three months later on the east coast, the onset of heavy autumn rainfall occurs simultaneously on both coasts. The causes of this discrepancy are multiple, but the immediate cause resides in the contrasting results of rain falling on high versus low water tables in salt marsh and mangrove swamp. The monthly mean sea level rises above the annual mean in May on the Gulf, and in September on the Atlantic coast. The contrast in tide pattern between the two coasts of Florida although greater than is found along the entire remaining coastline of the United States is less critical in the present context and need not be mentioned further.

Finally, Indian River is an ecological entity within the east coast in which autumn rains and run-off raise the water level more

rapidly than is compensated for between tides by discharge through the inlets into the ocean, and where tides are controlled more by wind than moon. All these factors contribute to the differential onset of high water on the two coasts of Florida which may not only govern the contrasting peaks of mosquito eruption but less obvious biotic schedules such as larval transformation and emigration and perhaps even the onset of spawning by tarpon if it occurs on both coasts.

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### *Ichthyococcus irregularis*, a New Gonostomatine Fish from the Eastern Pacific<sup>1</sup>

ANDREAS B. RECHNITZER AND JAMES BÖHLKE<sup>2</sup>

FOR approximately a century the genus *Ichthyococcus* Bonaparte (1840), of the family Sternopychidae, subfamily Gonostomatinae, was known only from the type spe-

cies *Ichthyococcus ovatus* (Cocco). In 1941

<sup>1</sup> Contributions from Scripps Institution of Oceanography, New Series, No. 970.

<sup>2</sup> The authorship is collaborative, the paper a combination of studies begun separately.

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Imai described *Ichthyococcus elongatus* on the basis of a single specimen from Sagami Sea, Japan. Three adults of this species were captured by the Research Vessel "Horizon", during the Northern Holiday Expedition of the Scripps Institution of Oceanography, in collection H51-359 (field no. NH9), at 41°42' N. Lat., 150°00' W. Long.; depth of water recorded at 2,700 fathoms (4,938 m.); calculated depth of haul (10-foot Isaacs-Kidd midwater beam trawl) 600-850 m.; GCT 5:52-8:30 p.m., 11 August 1951.

Recently 13 specimens of a form described herein as new have been taken in the tropical and temperate eastern Pacific by vessels from the same institution and three additional examples were taken earlier (1925) by the *Arcturus* Oceanographic Expedition of the New York Zoological Society. A large number of larvae of *Ichthyococcus*, thought to be the young of this species, have been taken off California and Baja California (Fig. 3).

*Ichthyococcus irregularis*, sp. nov.

Pl. I, Figs. 1-3

HOLOTYPE—U. S. National Museum (USNM) 169735, an adult 76 mm. in standard length, taken by the Research Vessel "Pacifica-T" off Baja California, Mexico, in collection H51-90, between 25°44' N. Lat., 114°52' W. Long. and 25°52' N. Lat., 114°40' W. Long.; depth of water "to 2,000 fathoms" (3,658 m.); calculated depth of haul (10-foot Isaacs-Kidd midwater beam trawl) 2,218 m.; 11:42 p.m. to 9:30 a.m., 21-22 March 1951.

Following are the data on the additional specimens that we have examined: Stanford University = SU 46348 (New York Zoological Society = NYZS 5975), 1 specimen (in poor condition), 34.2 mm. long, taken by the *Arcturus* Oceanographic Expedition of the New York Zoological Society at Sta. 74-OT3, 60 mi. south of Cocos Island; 4°50' N. Lat., 87°00' W. Long.; "nearest sounding 514-900 fathoms"; duration 1 hr., 29 min.; calculated depth of otter trawl 833 fathoms (1,524 m.); 2:11 p.m., 29 May 1925.

SU 46346 (NYZS 6276), 1 paratype, 33.0 mm. in standard length, taken on the same expedition at Sta. 84-T21, at the Galápagos Islands (Archipiélago de Colón) 1 mile north of Narborough Island (Isla Fernandina); 00°17' S. Lat., 91°34' W. Long.; nearest sounding 672 fathoms (1,229 m.); calculated depth of tow net 600 fathoms (1,097 m.); duration 1 hr., 32 min.; 2:06 p.m., 11 June 1925.

SU 46349 (NYZS 6313), 1 specimen (in bad condition), about 24.5 mm. long, taken on the same expedition at Sta. 86-PT1, 16 miles southwest of Narborough Island; 00°42' N. Lat., 91°47' W. Long.; nearest sounding 1,900 fathoms (3,475 m.); calculated depth of Peter-sen trawl 1,000 fathoms (1,829 m.); duration 51 min.; 9:39 a.m., 12 June 1925.

1 paratype, 34.3 mm. long, taken by the Research Vessel "Horizon" on Cruise 32, off central Baja California, in collection H51-406 (field no. H-32-1) between 27°17.6' N. Lat., 117°04.9' W. Long. and 26°56.8' N. Lat., 117°00.9' W. Long.; depth of water 3,292-3,658 m.; calculated depth of haul (10-foot Isaacs-Kidd midwater beam trawl) 2,926 m.; 7:10 p.m. to 7:50 p.m., 29-30 November 1951.

1 paratype, 47.5 mm. long, taken by the Research Vessel "Horizon" on the Shellback Expedition of Scripps Institution of Oceanography off Central America, in collection H52-390, between 08°09' and 08°16' N. Lat., along 84°58' W. Long.; depth of water 1,230 fathoms (2,250 m.); calculated depth of haul (10-foot Isaacs-Kidd midwater beam trawl) 450 m., 1:22 p.m. to 4:10 p.m., 31 July 1952.

2 paratypes, 27.5 and 38.6 mm. long, taken by Dr. Gordon Tucker on the Research Vessel "E. W. Scripps," in collection T319, at 32°47.4' N. Lat., 117°35.7' W. Long.; in a 6 x 6-foot beam tow net hauled obliquely to the surface from a depth of about 360 m. at a rate of 10 m. per min.; 9:55 to 10:35 a.m., 1 August 1952.

2 specimens about 21 to 33 mm. long, collected by the Research Vessel "Horizon" on the Eastropic Expedition of Scripps Institution in collection SIO 55-232 (field no. ET(B)-H-31); between 10°52' N. Lat., 88°02' W. Long. and 10°59' N. Lat., 88°05' W. Long.; depth of water 2,771-2,780 m.; calculated depth of haul (10-foot Isaacs-Kidd midwater beam trawl) 450 mm.; 7:55 to 10:15 p.m., 4 November 1955.

1 paratype, 31.5 mm. long, taken on same expedition between 02°00' S. Lat., 90°33' W. Long. and 02°03' N. Lat., 90°54' W. Long.; in collection SIO 55-258 (field no. ET(B)-H-58); depth of water 3,192-3,237 m.; depth of haul (10-foot Isaacs-Kidd midwater beam trawl) 1,509-1,692 m.; 8:20 p.m. to 1:45 a.m., 28-29 November 1955.

4 paratypes, 14.8 to 32.7 mm. long (in poor condition), taken on the same expedition in the eastern Pacific in collection SIO 55-265 (field no. ET(B)-H-65); 00°02' N. Lat., 100°23' W. Long.; depth of water 3,283-3,457 m.; calculated depth of haul (10-foot Isaacs-

Kidd midwater beam trawl) between 1,107 and 1,335 m.; 12:35 to 4:45 a.m., 6 December 1955.

2 specimens, about 28 mm. long (badly damaged), taken on the Eastropic Expedition between 10°52' N. Lat., 88°02' W. Long. and 10°59' N. Lat., 88°02' W. Long. in collection SIO 55-232; water depth 3,000 m.; depth of haul (10-foot Isaacs-Kidd midwater beam trawl) 445-326 m.; 7:55 p.m. to 10:15 p.m., 4 November 1955.

Since no closing device was used on these midwater trawl hauls, the specimens were subject to capture during the lowering and raising of the net.

All specimens other than the holotype and those bearing Stanford University identification numbers are deposited at the Scripps Institution of Oceanography.

The following key is based primarily on an examination of the specimens of *I. elongatus* and *I. irregularis* just recorded and on three of *I. ovatus*. One of the *I. ovatus* specimens, SU 9502, taken at Messina, Italy, came from the Royal Zoological Museum at Florence. Two others (H52-199 in Scripps Institution of Oceanography) 39.5 and 41.0 mm. long, were taken at Sta. 1370 I, at 36°36' N. Lat., 26°14' W. Long., with 1,000 m. of wire out, at 2:30 a.m., 13 June 1922; "Redskat; E 300"; they were sent from the Carlsberg Laboratorium by Å. Vedel Tåning. The study of these specimens has been supplemented by an examination of the accounts of the species of the genus by Brauer (1906: 94), Jespersen and Tåning (1926: 38), Imai (1941: 234), Borodin (1931: 69), Sanzo (1931: 49), and Norman (1939: 20).

#### KEY TO THE SPECIES OF *Ichthyococcus*

A. Dorsal rays 10-13; gillrakers 15-19 on lower limb of first arch; photophores in upper series totaling 23-26; greatest depth of body 2.3-3.1 in standard length; scales in a lateral series 32-39; vertebrae 38-39.

B. I-P series of ventral photophores in a straight line when viewed from below, with No. 8 only displaced laterally; A-C series continuous; interorbital region extremely narrow, with a median longitudinal ridge (Mediterranean Sea, eastern Atlantic Ocean, and, reportedly, Indian Ocean). . . . *I. ovatus*

BB. I-P series of photophores highly irregular (Fig. 1 and Pl. I); No. 8 displaced far outward; No. 9 displaced inward (and reduced in size); No. 10 displaced moderately outward, and Nos. 10 to 14 of each side converging posteriorly; A-C series interrupted; interorbital region comparatively broad, without a median ridge, but with lateral longitudinal ridges or flanges on either side (eastern Pacific) . . . . *I. irregularis*

AA. Dorsal rays 15; gillrakers 24-26; photophores in upper series 31; greatest depth of body 4.6; scales 42-44; vertebrae 47. Photophores arranged as in *ovatus*; interorbital rather broad and flat, approaching that of *irregularis* (northeastern Pacific and North Pacific Drift) . . . . *I. elongatus*

#### DESCRIPTION

D. 11 or 12; A. 13 (13-15); P 8/8;  $P_2$  7/7; lateral scales 35 (34-36); gillrakers of first

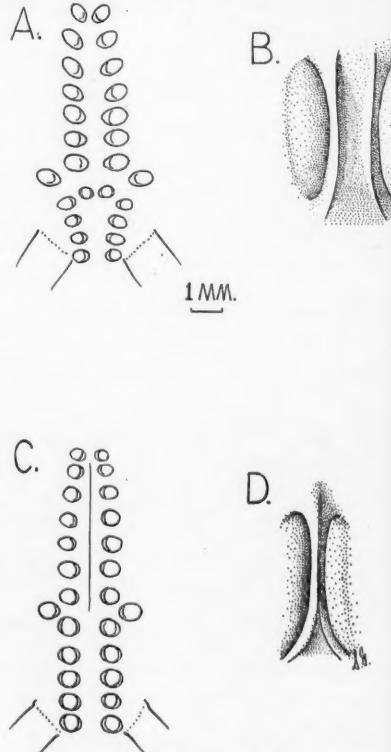


Fig. 1. Pattern of prepectoral photophores and form of interorbital in *Ichthyococcus irregularis* (A and B) and in *I. ovatus* (C and D), drawn from specimens SU 46346 and 9502, respectively.

arch usually 8 + 17-19. Depth of body averaging 2.8 (range 2.6-3.0); length of head 2.8 (2.6-3.1); snout to dorsal 2.0 (1.9-2.1); snout to adipose 1.3 (1.3-1.4); snout to pectoral 3.0 (2.8-3.2); snout to pelvic 1.7; snout to anal 1.3, and least depth of caudal peduncle 9.3 (8.2-10.1), all in standard length. Diameter of eye 3.0, length of snout 3.7, width of bony interorbital 8.4, snout to end of maxillary 2.1, length of pectoral 1.5, length of pelvic

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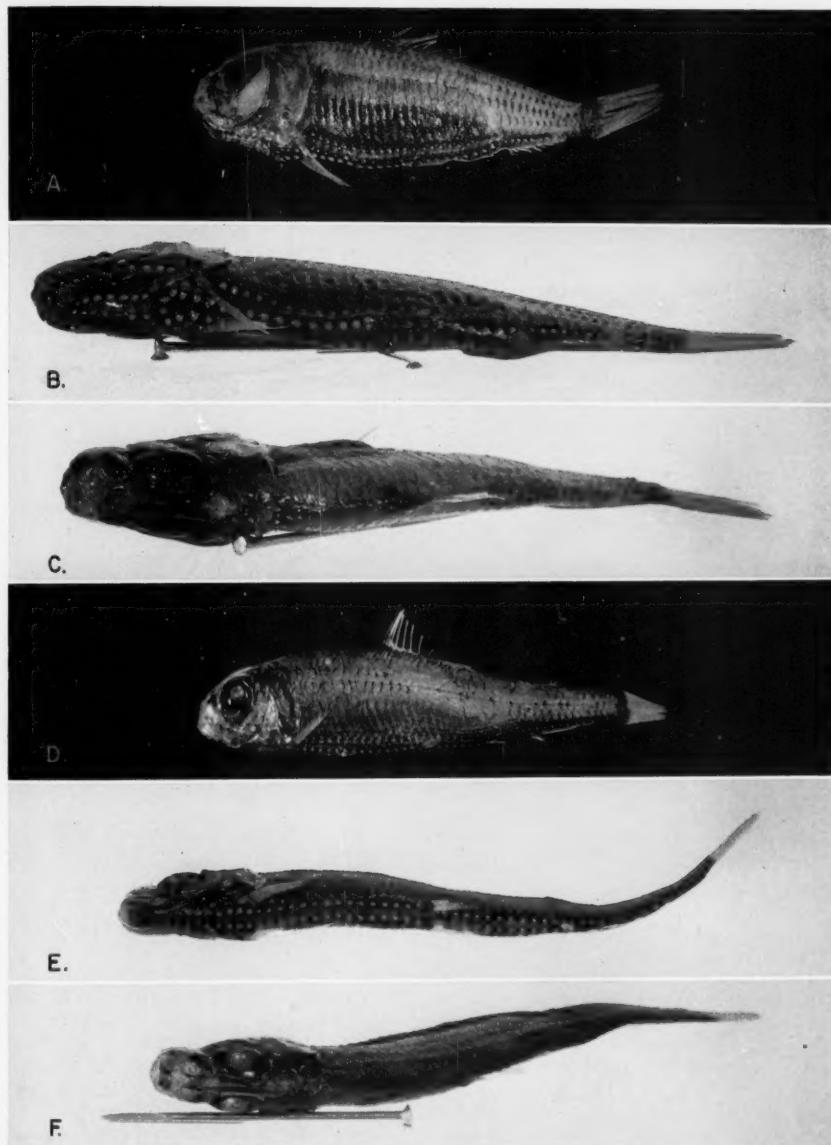


Plate I

A-C. *Ichthyooccus irregularis*: lateral, ventral, and dorsal views of holotype (76 mm. standard length); collected at 25°44'N. Lat., 114°52'W. Long.; USNM 169735.

D-F. *Ichthyooccus elongatus*: lateral, ventral, and dorsal views of specimen (H51-359) from eastern Pacific 41°42'N. Lat., 150°00'W. Long., 78 mm. long.

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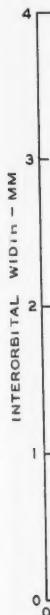


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2.2, length of dorsal base 1.7, length of adipose base 2.2, and length of anal base 2.5, all in head length.

Body shape same as that of *Ichthyococcus ovatus* (Fig. 23, one of Jespersen and Tåning, 1926). Greatest body depth at origin of dorsal, which is equidistant from tip of snout and base of caudal fin. Pelvic fins inserted below the interspace between the seventh and eighth dorsal rays. Anal originating behind

occurred which distinguish this species. In *ovatus* the only photophore that is out of line is No. 8, which is displaced about its full width outward. A similar displacement occurs in the other species. In *irregularis*, in addition, photophore 9 is displaced inward so that the pair of the two sides lie close together, and this organ is somewhat reduced in size; No. 10 is displaced outward a little, and Nos. 10 to 14 of each side converge pos-

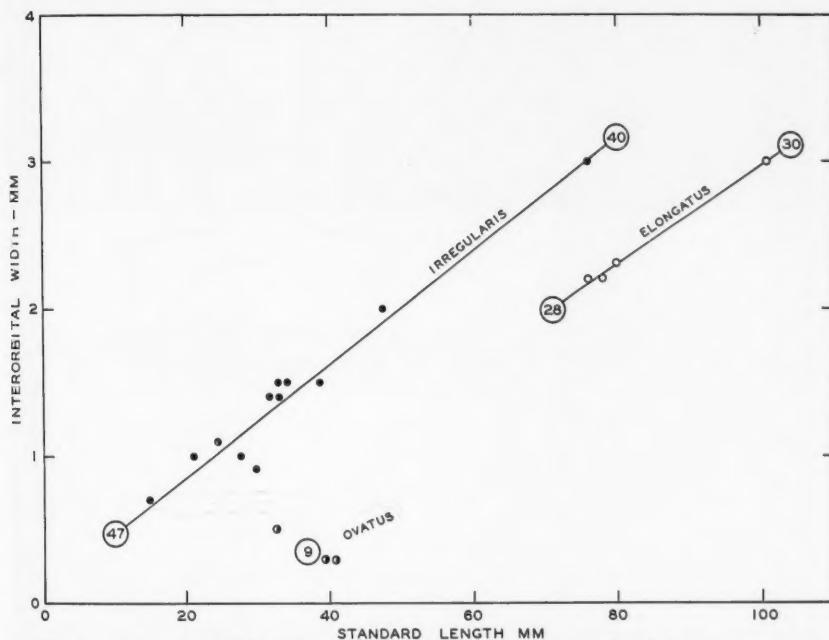


Fig. 2. Relation between least bony interorbital width and standard length in the three species of *Ichthyococcus*. The ringed figures indicate proportions, at indicated points, as thousandths of standard length.

a vertical through origin of adipose dorsal. Pectorals not nearly reaching pelvics; pelvics failing to reach to anus.

Five photophores on either side of head: one before eye, one below eye, one at angle of preopercle, one on lower portion of opercle, and one at upper end of opercle. Branchiostegal series 12. In the upper lateral series P-V 13, V-A 10. In the lower lateral series: I-P 11 (plus an additional organ lateral and adjacent to the interspace between photophores 7 and 8 of the main series), P-V 13, V-A 9, A-C 12-13 (usually 7 + 5). It is in the I-P photophores of the ventral series that most of the modifications have

teriorly. From back to front, the two ventral series diverge evenly (beginning below the pectoral base) to photophore 10 mentioned above; in fact, the photophore 8 of the I-V series might be considered the anterior member of this series, which has flared out laterally, were it not for the simpler pattern displayed by the other species. It is certainly in line with them (Pls. IB and E, IIB).

Scales cycloid, thin, very deciduous. The counts in the accompanying table are made from scale pockets and the vertical pigment streaks, each of which appears to correspond to one scale.

Interorbital space broad, flat in the middle,

rising on either side to a longitudinal ridge (Fig. 1 and Pl. IC). This condition contrasts sharply with that in *I. ovatus*, in which the interorbital is narrow, with a median ridge

#### DISTRIBUTION

So far as known, the three species of *Ichthyococcus* are allopatric. *I. ovatus* is definitely known from the Mediterranean Sea

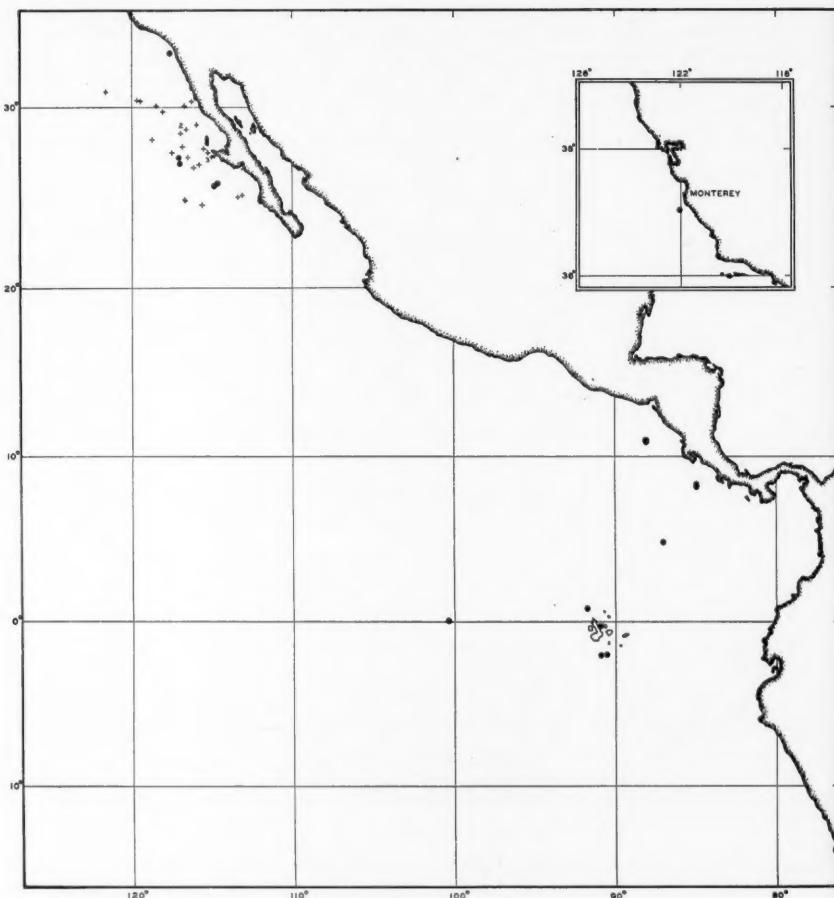


Fig. 3. Known distribution in the Pacific Ocean of *Ichthyococcus irregularis*. (solid circles) Known distribution in the Pacific Ocean of larvae of *Ichthyococcus* presumed to represent *irregularis*. (crosses) Most specimens were collected off Baja California due to extensive collecting in this area. Presumably additional larvae and adults will be collected in other areas, particularly in more tropical waters.

(Fig. 1 and Pl. IIC). Differences in the relation between interorbital width and standard length are trenchant (Fig. 2).

#### DERIVATION OF NAME

The name *irregularis* refers to the irregular arrangement of the ventral photophores before the pectoral fin.

and the eastern Atlantic Ocean, and has been reported (Brauer, 1906: 96; Norman, 1939: 20), from the Indian Ocean. On the basis of two young specimens that may represent *I. irregularis*, Brauer counted 12 branchiostegal photophores, as we do in *irregularis*, and he figured the anal series as interrupted—as it is in *irregularis*. Our material of *irregularis* all

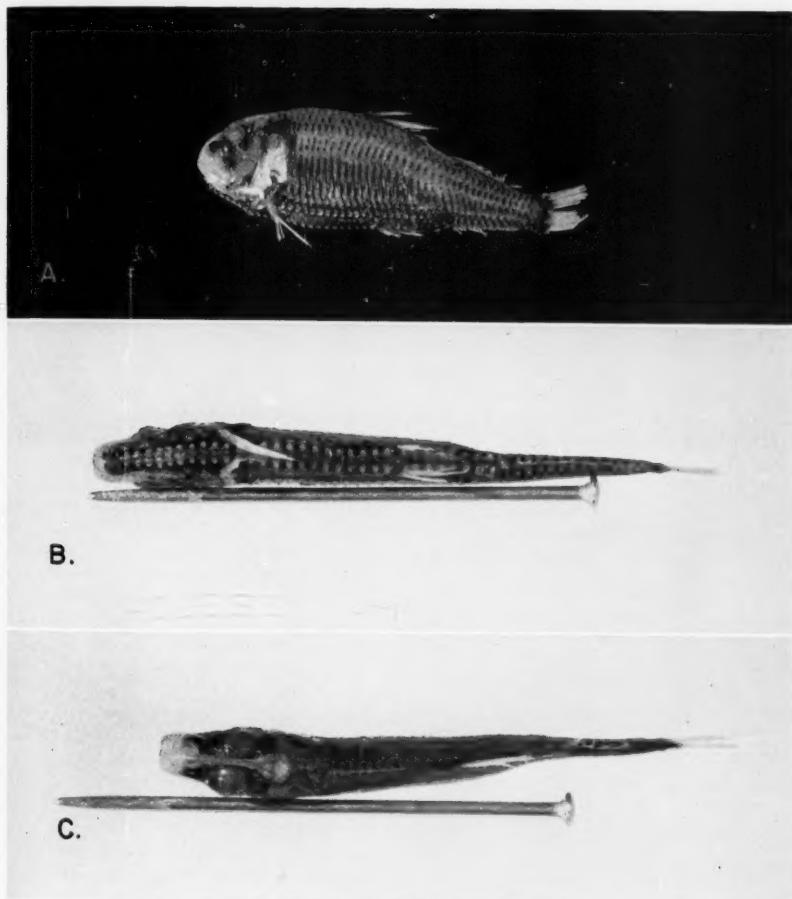


Plate II

A-C. *Ichthyococcus ovatus*: lateral, ventral, and dorsal views of specimen H52-199 from Atlantic Ocean, 36°36'N. Lat., 26°14'W. Long., 39.5 mm. long.

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comes from the eastern Pacific, from tropical waters to off southern California. One of the collections of larvae, presumed to be of this species, is from off central California, to which region it might have been carried by the Davidson Counter-current. *I. elongatus* appears to be one of the species of the northwestern Pacific that ranges into the northeastern Pacific along the North Pacific Drift.

#### RELATIONSHIPS

*Ichthyococcus irregularis* is most similar, and presumably most closely related, to *I. ovatus*, contrasting in several respects sharply with *I. elongatus* (as is indicated in the key). *I. irregularis* and *I. ovatus* have the same general body form and are very similar in meristic counts. Both contrast with *elongatus* in their relatively short and deep bodies and in the reduced numbers of vertebrae, scales, dorsal rays, photophores, and gillrakers. *I. irregularis* contrasts with *I. ovatus* (and also with *elongatus*) in the odd arrangement of the ventral photophores before the pectoral fin (Fig. 1 and Pl. I) and in the interruption of the anal series of photophores; it also has a much wider interorbital (Figs. 1-2) with raised rims and no median ridge (in which respect *elongatus* is more like *irregularis* than *ovatus*). Less trenchant differences between *irregularis* and *ovatus* are the somewhat lower counts of anal rays, caudal vertebrae, P-V photophores both lateral and ventral, and A-C photophores; and the slightly more numerous gillrakers.

These three well-differentiated species form a series that parallels within limits the striking evolutionary sequence (Gonostomatinae—Maurolicinae—Sternoptychinae) that led Hubbs (1953) to refer all these diverse types to one family (Sternoptychidae). The sequence in *Ichthyococcus* is *elongatus*—*ovatus*—*irregularis*. *I. elongatus* most nearly approaches the generalized attenuate gonostomatines, such as *Vinciguerria*, and is presumably the most primitive form. In the evolutionary sequence the body becomes deep and foreshortened, with an enlarged head region, and with a reduced number of segmental structures. The interruption of the anal photophores is in the same line of evolution, and the out-of-line arrangement of the anterior ventral photophores is an obvious specialization. An enlargement of the photophores, especially in the vertical axis, marks both the species sequence and the subfamily sequence.

#### ACKNOWLEDGMENTS

We wish to thank Dr. George S. Myers and Miss Margaret Storey of the Natural History Museum of Stanford University for the loan of material of *I. ovatus* and of the new species; Dr. A. Vedel Tåning of the Carlsberg Laboratorium for two specimens of *I. ovatus*, which are now a part of the Scripps Institution of Oceanography collection; Dr. Gordon H. Tucker of San Diego State College for two specimens of the new species; Dr. Elbert H. Ahlstrom for identifications and distribution data on the larvae presumed to represent *I. irregularis*; and Dr. Carl L. Hubbs of the Scripps Institution of Oceanography, who originally participated in the identification of the new species, for numerous helpful suggestions and for a critical examination of the manuscript.

Our thanks to Dr. Denys Tucker of the British Museum (Natural History), for re-examining a single, 13 mm., nearly broken specimen reported by Norman (1939: 20) to most likely be *I. ovatus*. Using our key he confirms the identification, but retains some reservation for change because of its poor condition.

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U. S. NAVY ELECTRONICS LABORATORY, SAN DIEGO 52, CALIFORNIA, AND ACADEMY OF NATURAL SCIENCES, PHILADELPHIA 3, PENNSYLVANIA.

## Life History of the Pigmy Seahorse, *Hippocampus zosterae* Jordan and Gilbert, at Cedar Key, Florida<sup>1</sup>

## KIRK STRAWN

**L**ITTLE is known of the life history of the pigmy seahorse, *Hippocampus zosterae*.<sup>2</sup> From June, 1948 to June, 1957, large samples were taken at Cedar Key, Levy Co., Florida. From February, 1950 to February, 1951, bimonthly collections were made at 28 stations on three grass flats during spring tide periods. Further data were obtained from seahorses collected in other parts of the Gulf of Mexico, including some from Harbor Island, Texas, which were kept alive at The University of Texas. Pushnets (Strawn, 1954a), beam trawls, and minnow seines were used to collect seahorses. Seining was discontinued when it was discovered that one person could collect more seahorses with a pushnet than two could with a seine. Three-eights-inch stretched mesh netting was used in both the pushnets and trawls because only small seahorses could go through it.

Cedar Key specimens, except for a few found on vegetation floating in the channels, were taken on the grass flats bordering the islands or between these keys and the mainland. The grass flats in this area are restricted to above the extreme low water mark except for limited fringes. Deeper grass flats in clearer offshore water were not investigated. The angiosperms growing on the grass flats at Cedar Key are: *Diplanthera wrightii* (Ashers); widgeon grass, *Ruppia maritima* L.; *Halophila engelmanni* Ashers; turtle grass, *Thalassia testudinum* König; and manatee grass, *Syringodium filiforme* Kütz.<sup>8</sup> Of the three most conspicuous plants, *Diplanthera* occurs in the shallowest water, *Syringodium* is predominant in the deepest water, and *Thalassia* is mixed in at intermediate depths. In the spring, summer, and fall the seahorses live wherever these plants occur. In the winter, when leaves exposed to the air during low tide are killed back by desiccation, seahorses tend to concentrate in deeper water and in tide pools where the vegetation

is the heaviest. In addition to the seed plants, year-round residents, numerous algae flourish and become extremely abundant on parts of the grass flats in the spring.

A report of size, sex, location caught, and type of net used is given by Strawn (1953). Nearly all sea horses collected from February, 1950 through February, 1951, are plotted in Figure 1 by sex, length in mm., and the time of year taken. The variation in the number of seahorses plotted in this figure for different collecting periods is as much the result of variation in the excellence of collecting conditions and of collecting intensity as of changes in population size. The length was measured, following Ginsburg (1937), from the tip of the coronet, the knob on top of the head, to the tip of the tail. This measurement was made by placing a fish on a millimeter rule with the tip of the coronet at the 0 mm. mark and with the axis of the head held perpendicular to the tail. Forceps were used to uncoil the tail. Every attempt was made to exert as little pressure as possible in straightening the tail because stretching would add as much as a millimeter to the length measured. Many of these specimens were remeasured three years later, and while many measured a millimeter longer, none varied by more than one millimeter from the original measurements. Ginsburg used calipers while holding the tail straight with a glass slide. He held the lower profile of the head at right angles to the tail which gives essentially the same measurement on these small seahorses as the method used in this study. Measurements, taken to the closest millimeter, ranged from 7 to 38 mm.

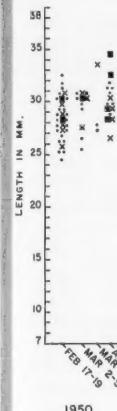
### SEX RATIO

The sex of seahorses 16 mm. long collected in the summer could be determined by the presence or absence of a brood pouch. In specimens of this size the brood pouch was represented ventrally on the first few caudal segments by an elevated ridge surrounding the area of the future pouch. At the end of the breeding season, the last of October, the ridges were not present in individuals under 18 mm., and in the middle of December, a 20 mm. male had the stage of development characteristic of the 16 mm. males of summer.

<sup>1</sup> An enlargement of part of a master's thesis prepared at The University of Florida, 1953. The last phases of this study were supported by a Duke University Marine Laboratory National Science Foundation Grant 1957.

<sup>2</sup> National Science Foundation Grant, 1957.  
*Hippocampus regulus* Ginsburg is here considered a synonym of *H. zosterae*. Populations with a mode of 11 dorsal rays range from Mexico to Cedar Key, and populations with a mode of 12 dorsal rays occur from Tampa Bay to Key West and Biscayne Bay, Florida.

<sup>3</sup> See Thorne (1954) for a discussion of flowering plants of the Gulf of Mexico. Dandy and Tandy (1939) found *Cymodocea manatoria* Ashers to be a synonym of *Syringodium filiforme* Kütz.



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Data presented in Table I show the sex ratio of the collected plants with 2 stations. The ratio of air to air is the same as back by direct count. There were 1000 plants during all the counts, and there were 500 males during the counts on April 22, 1950; the approximate ratio of the sex ratio of the plants with 1 station is the same as the ratio of the plants in the field. A difference is found, however, than that found in the chance basis of the investigation.

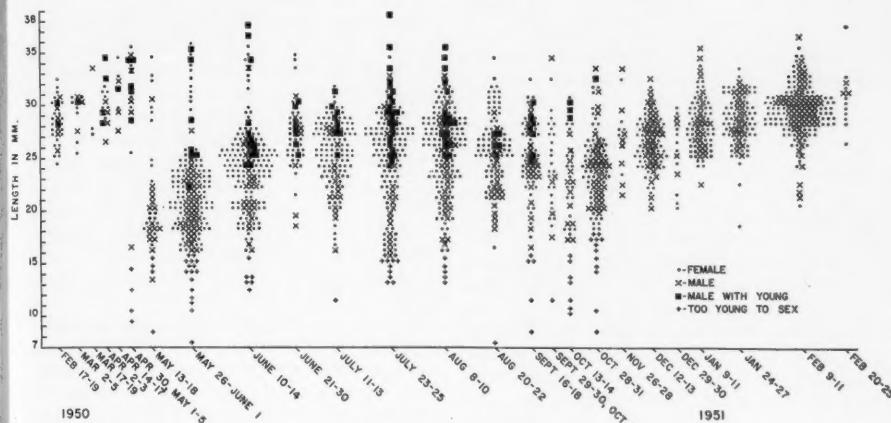


Fig. 1. Length frequency distributions of the pigmy seahorse at Cedar Key.

Males below these seasonal lengths rarely had recognizable ridges.

In collections made at Cedar Key, females outnumbered males throughout the 12-month period (Table I). Collections made February 17 and 18, 1951, south of the west end of Gandy Bridge, Old Tampa Bay, Pinellas Co., Florida, contained 394 fish of which 47.71 percent were males. Gudger (1906) stated that female pipefish, *Syngnathus floridae* Jordan and Gilbert, at Beaufort, North Carolina, outnumbered males seven to three. This is similar to the summer ratio found in *H. zosterae* at Cedar Key.

Data presented in Table II indicate that the sex ratio obtained can be influenced by the collecting site. Group 1 stations had plants with longer living leaves than Group 2 stations during the winter when exposure to air is the greatest and the plants are killed back by desiccation. On the Group 2 stations there were about two females to one male during all seasons. On the Group 1 stations there were two females to one male only during the period from May 27 to August 22, 1950; all the rest of the year there was approximately one female to one male. When sex ratio of seahorses collected on the Group 1 stations in the summer is compared to the ratio of those collected on the Group 1 stations in the fall a  $X^2$  value of 9.2 is obtained. A difference in sex ratios as great as or greater than that observed could be expected on a chance basis less than once in two hundred investigations. The sex ratio of the fall Group 1 sample compared to that of the fall Group 2 sample gives a  $X^2$  value of 3.7 and a probability of .06. The difference between the sex

ratios of these two samples, therefore, is not of conventional statistical significance but is suggestive. Thus, the sex ratio of a sample of pigmy seahorses is definitely correlated with the season and, probably, with the types of environmental vegetation.

TABLE I  
PER CENT OF MALE TO FEMALE PIGMY SEAHORSES  
AT CEDAR KEY FROM FEBRUARY 17, 1950 TO  
FEBRUARY 11, 1951

	Number	Per cent	
		♀ ♀	♂ ♂
Feb. 17-May 18	115	57	43
May 26-Aug. 22	854	69	31
Sept. 16-Oct. 31	211	57	43
Nov. 26-Feb. 11	407	57	43
Total for year	1587	63	37

TABLE II  
SEX DISTRIBUTION OF THE PIGMY SEAHORSE ON  
GROUPED STATIONS AT CEDAR KEY FROM  
FEBRUARY 17, 1950 TO FEBRUARY 11, 1951

	Group 1 Stations		Group 2 Stations			
	Total	Per Cent		Total		
		♀ ♀	♂ ♂			
Feb. 17-May 18	41	51	49	32	66	34
May 27-Aug. 22	325	67	33	178	71	29
Sept. 16-Oct. 31	91	49	51	53	66	34
Nov. 26-Feb. 11	101	52	48	9	67	33

## BREEDING SEASON

Males with young were found during the period extending from late February, 1950 to the end of October, 1950 (Fig. 1). Other indications of breeding are a flabby pouch on males without young and females with full bodies and large eggs in the ovaries. A courting male pumps his pouch full of water until it looks like a balloon ready to burst. In contrast, the pouch of a male out of breeding season is a shriveled structure that requires modification before it can be distended. Data indicate that breeding commences in early or mid-February and ends by late October or early November. During September and October of 1948, extensive collections were

TABLE III  
NUMBER OF MALE PIGMY SEAHORSES AT CEDAR  
KEY WITH AND WITHOUT YOUNG IN POUCH FROM  
FEBRUARY 17, 1950 TO FEBRUARY 11, 1951

	22-24 mm.			25 mm. and larger		
	With	Without	Per Cent With	With	With- out	Per Cent With
Feb. 17-March 19	0	0	0	3	10	23
Vernal to Au- tumnal Equi- nox						
(April 1-Sept. 18)	7	55	11	100	57	64
Sept. 29-Oct. 31	0	25	0	4	15	21
Nov. 26-Feb. 11	0	14	0	0	158	0

made in search of males with young in their pouches. Few were found after late September, and no males with young were caught after the middle of October. In the falls of 1949 and 1950, a similar decrease in breeding was observed though one gravid male was collected the last of October in 1950. By late October, 1950, most males had shriveled pouches, and the few females with eggs contained exceptionally small numbers. None of the males collected in November and December of 1948 and December, 1949, had young in their pouches. From November 26, 1950 to February 11, 1951 (Table III), none of 158 males, 25 mm. or longer, were gravid. A collecting trip in early March, 1949, produced gravid males. On February 19, 1950, two males containing advanced embryos and several females with large eggs were taken. One of these males had almost fully developed young that by warm water Harbor Is-

land, Texas standards (Strawn, 1954b) must have been in the pouch for about 9 days and probably longer since the developmental rate should be slower at winter temperatures. Thus males with young and females with ripe eggs most certainly were present by the tenth of February, 1950. Large series of seahorses were collected with a trawl on February 9-11, 1951, to ascertain whether breeding had started as early as it had the preceding year. Some of the females had partially developed eggs whereas no macroscopic eggs had been apparent in December, but all of the males still had shriveled brood pouches. Two of five females collected February 23, 1951, had large ovarian eggs and the one male had a flabby brood pouch. Farther south the breeding season starts earlier and ends later. On February 17 and 18, 1951, 74 of 188 males taken south of the west end of Gandy Bridge, Pinellas Co., Florida, were gravid. These are considered to be the first broods of the year since only one male had fully developed young. Breder (1940) observed a Palmetto Key fish (Lee Co., Florida, almost due west of Fort Myers) give birth to a brood on February 9, 1939. Two of four breeding size males and two of three adult females collected by Royal D. Suttkus and Edwin B. Joseph at Key Largo, Monroe Co., Florida, on November 17, 1953, were gravid.

The breeding season appears to correlate closely with seasonal changes in the length of day. This is inferred from the proportion of 25 mm. or longer males which had young in the brood pouch during different seasons. Although males with young in the pouch ranged from 22 to 38 mm., those under 25 mm. are of little use for this purpose since only seven of these contained young. The number and per cent of males 22-24 mm. and 25-38 mm. with and without young are given in Table III. It may be seen that during the period between the vernal and the autumnal equinox about two-thirds of the 25 mm. or longer males had young in the pouch, while in the 36 days following the autumnal equinox and the 30 days preceding the vernal equinox, less than one-fourth had young. During the period from November 26, 1950 through February 12, 1951, none had young out of a total of 158. In terms of hours of sunshine per day (Marvin, 1944) this means that no breeding was found during less than 11.1 hours light, fewer than one-fourth of the males were breeding with 11.1 to 12.1 hours light, and about two-thirds of the males were breeding with over 12 hours light.

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Channel temperatures (Fig. 2) are not closely correlated with the breeding season of *H. zosterae* at Cedar Key. Breeding stopped in the fall when the channel temperatures were still much higher than when breeding was first observed in the late winter and spring. Breeding continued during March and April at temperatures lower than those found when breeding ceased in the fall. Although temperature does not correlate closely with the beginning and end of the breeding season, it may be important as a wide limit. The earlier start of the breeding season in 1950 than in 1951 may be the result of the warmer January and early February temperatures of 1950 (Fig. 2).

Salinity appeared to have had little effect

on the breeding season. The large, yolked eggs of the following batch. This sharp contrast in size between immature and ripe eggs differs strongly from that found in the northern greenside darter, *Etheostoma blennioides* Rafinesque, by Fahy (1954). His plots of egg size show a bimodal curve consisting of a large peak representing numerous future batches and a smaller peak formed by the large, maturing eggs of the next batch. The eggs of the second batch are not included in the counts. With few exceptions only females with large mature or nearly mature eggs were used for egg counts. The largest batch found in the ovaries of a female (34 mm.) was 69, and the most young taken from the pouch of a male (31 mm.) were 55. The numbers of eggs though similar are rarely

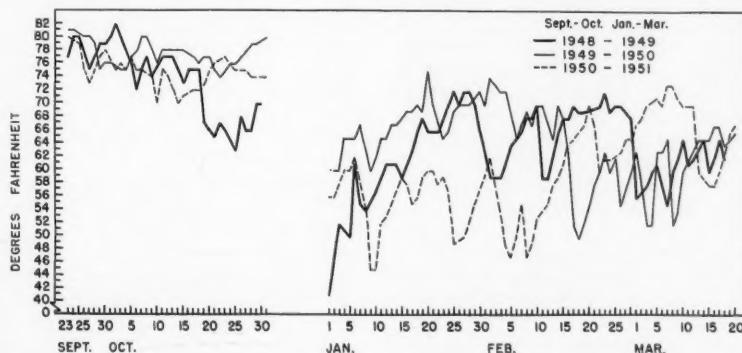


Fig. 2. Cedar Key Tide Station water temperatures following the autumnal equinox and preceding the vernal equinox.

on the breeding season in 1950. Heavy breeding occurred following the periods of highest (33.8 0/00) and lowest (9.7 0/00) salinities in June, 1950, and in the middle of September, 1950, respectively, as well as at intermediate salinities.

Seasonal changes in the percent of time the flats were exposed to the air at low tide did not delimit the breeding season. Breeding occurred in late winter and early spring during periods of extreme exposure and in August when exposure was the least. Possible peaks in breeding caused by changes in tide level or amount of moonlight during the lunar month (Korringa, 1947) were not obvious from the data and were not investigated.

#### CONTENTS OF OVARIES AND BROOD POUCHES AND FREQUENCY OF BROODS

Under the magnification used (12.5 $\times$ ) a ripe ovary contains large eggs ready to be injected into the pouch of the male and minute,

evenly divided between the two ovaries. Large eggs are of similar size, except for an occasional undersized one which will produce an inviable runt in the pouch of the male, and are easily counted while small eggs are variable in size and are difficult to count. Fully mature eggs are rounded and tend to be loose in the ovary while less mature eggs are tightly packed and angular. Egg-like structures containing yolk were counted as eggs whereas pieces of a translucent material that sometimes are present in an ovary and may even completely surround some of the eggs were not counted. The female evidently dumps the whole contents of the ovary into the pouch of the male, and in some cases this includes what appears to be all the large eggs in the ovary still tightly joined together, angular in shape, and covered by maternal membranes. Even under these seemingly abnormal conditions most of the eggs have a developing embryo. For purposes of comparision

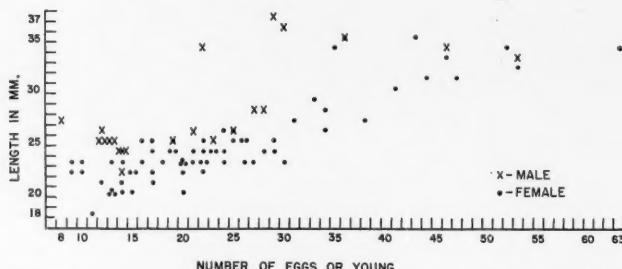


Fig. 3. Lengths of pigmy seahorses plotted against number of large eggs in the ovaries of the females and eggs or young in the pouches of males collected on May 27-30 and June 10-14, 1950, at Cedar Key.

son, all living and dead eggs and egg-like structures in the pouches of males were counted the same as they were counted in the ovaries of the females. During the main part of the breeding season less than 1 percent of the eggs in the pouches were inviable. Non-egg ovarian material and unseparated eggs were also rare in the summer of 1950. Many of the 74 gravid males collected at the start of the breeding season near Gandy Bridge, February 17 and 18, 1951, contained a few inviable eggs, non-egg ovarian material and unseparated angular eggs. Only one gravid Cedar Key male (30 mm., collected February 19, 1950) of 96 examined contained more than one age group in his pouch. Five were well developed with little yolk sac and 12 were less fully developed with larger yolk sacs. This is another example of atypical contents in the brood pouch at the start of the breeding season. From the fact that the young in all but one of the males examined appeared to be of the same age and from the general similarity in numbers of eggs in the females and males shown in Figure 3, it is concluded that one female usually furnishes all the eggs found in the pouch of a male. Data on seasonal changes in fecundity and mate selection in relation to size will be published elsewhere.

Between mid-June and late August, 68 percent of the males 25 mm. or longer had young in their pouches. Harbor Island males at about 85°F. (a temperature believed to be comparable to the average summertime temperature on the grass flats at Cedar Key) carried their young for approximately 10 days, and one male gave birth to two broods within 12 days (Strawn, 1954b). Presuming Cedar Key males carry their broods for 10 days and that these 10 days represent 68 percent of the time for the average male, then the 32 percent of the time they are without young

would be 4.7 days. Thus broods are about 14.7 days apart, and a male produces two broods per month. Data on the greenthroat darter, *Etheostoma lepidum* (Girard), indicate that more frequent broods are to be expected at higher temperatures and the reverse at lower temperatures (Strawn, 1957).

#### GROWTH, SEXUAL MATURITY, AND NUMBER OF GENERATIONS A YEAR

Newborn young in two broods of Cedar Key *H. zosterae* ranged from 7 to 9 mm. so the fish of this size in Figure 1 are either newborn or are certainly less than a week old, judging by the growth rates of aquarium raised specimens from Harbor Island, Texas, plotted in Figure 4. The latter were raised, under constant light, in a two gallon glass

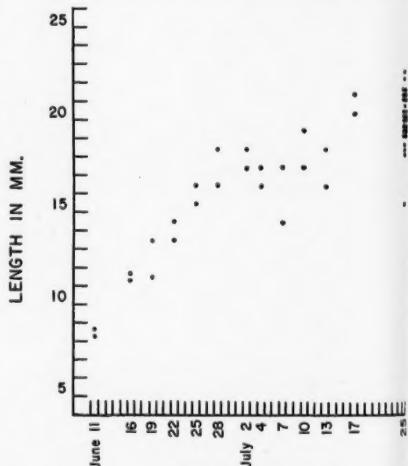


Fig. 4. Growth rate of a brood of pigmy seahorses from Harbor Island, Texas, born June 11, 1951.

goldfish in the new Society for the 17 d about 8 brood ra ditions a During season at least three mination. Key sea breeding when no enables growth rapid A young (1 of young the result. Males and early months were col 1950, the in late M extensive o earlier. In half of F they wou The rapid during M suggests warm we month-of Island p 19 of the pouches, in runn Marine 1957, bro Cecil Bo horses in um bor months. a seahors than suf three gen the end Two and a possibl during t May to 1 erations

The p high rate

goldfish drum at about 85°F. and were fed all the newly hatched San Francisco Aquarium Society brine shrimp they could eat. During the 17 days following birth they grew from about 8 mm. to as long as 18 mm. Another brood raised to maturity under similar conditions at the same time grew even faster. During most of the year the long breeding season coupled with the production of at least three generations a year make the determination of the growth rates of wild Cedar Key seahorses difficult. The break in the breeding season from November to January, when no young are added to the population, enables one to observe the slow average growth rate of the overwintering fish and the rapid April through June growth of their young (Fig. 1). The apparent slow growth of young of the year prior to May may be the result of cold water temperatures.

Males born in the cold water of late winter and early spring evidently take about three months to mature. Small males with young were collected as early as mid-May, 1949. In 1950, the first small gravid males were taken in late May (Fig. 1), but it is likely that intensive collecting would have yielded them earlier. If these males were born in the last half of February, early in the breeding season, they would be a little over three months old. The rapid growth rate at higher temperatures during May and June, evidenced in Figure 1, suggests attainment of breeding size during warm weather in less than three months. Two-month-old laboratory raised fish of Harbor Island parentage were of breeding size, and 19 of the 22 males had fully developed brood pouches. Fish from Pinellas Co., Florida, kept in running sea water at Duke University Marine Laboratory during the summer of 1957, bred at a little less than two months. Cecil Boyd, who bred Florida pigmy seahorses in Ocean Beach, California, had aquarium born males gravid at the age of two months. Three months between the birth of a seahorse and the birth of its young is more than sufficient time for the production of three generations between late February and the end of the breeding season in October. Two and a half months between generations, a possible figure judging by laboratory data, during the warm period from the last of May to late October would permit four generations a year.

#### LONGEVITY

The pigmy seahorse at Cedar Key has a high rate of reproduction combined with a

relatively stable population size and must be an important link in the food chains on the grass flats. Few would be expected to die of old age. Though I know of no reference to predation on the pigmy seahorse, there are several references to seahorses as fish food. Jordan and Gilbert (1882) named a large seahorse, *Hippocampus stylifer*, taken from a red snapper stomach. Longley and Hildebrand (1941) mention 20 specimens of *Hippocampus punctulatus* Guichenot taken from the stomach of a remora, and Herald (1949) discusses a seahorse that appeared among the stomach contents of a yellowfin tuna. *H. zosterae* maintains a relatively stable non-breeding population during the winter when many of the possible predators are scarce or absent from the shallow water of the grass flats. One of these, the blue crab, *Callinectes sapidus*, is extremely abundant on the flats in the summer and it frequently captures and devours the pipefishes, *Syngnathus floridae* and *S. scovelli* Jordan and Gilbert, caught with it in the pushnet.

The overwintering Cedar Key pigmy seahorses disappear from the flats by early August and do not become members of the next year's overwintering population (Fig. 1). A collection of 394 overwintering pigmy seahorses, made south of the west end of Gandy Bridge on February 17 and 18, 1951, had no individuals of a size that would indicate that they had previously overwintered. Cedar Key fish would be up to 8½ months old at the end of the breeding season in early November, and the 38 mm. male taken July 24, 1950, (Fig. 1) would be between 9 and 17½ months old. Judging by late spring and early summer growth rates the bulk of the fish present at the end of October are not over three months old, and thus it is a rare seahorse that survives over a year. Overwintering pigmy seahorses can survive past August. A male, collected at Harbor Island, Texas, the last of January, lived in The University of Texas aquarium room until the following November, and it might have survived longer with better care. Blair (1948) states that the calculated life span of small mammals living in the bluegrass field and meadow associations in Southern Michigan is only a fraction of the age attained by the same or similar forms in captivity, and he attributes this almost entirely to predation. Another possible reason for the disappearance of fish from the flats could be dispersal. During the late summer children at Cedar Key find pigmy seahorses clinging to drift along the beaches away from

grass beds, and following storms these fish can be found on vegetation floating in the channels. Many Tampa Bay pigmy seahorse fishermen believe that pigmy seahorses move with the tidal currents from one area to another.

#### SUMMARY AND ACKNOWLEDGMENTS

Females outnumbered males throughout the year. Season and environment can influence the observed sex ratio. The breeding season extends from mid-February to late October and is associated in time with days having over 11 hours of sunshine. A maximum of 69 large eggs was found in the ovaries of a female, and up to 55 young were counted in the pouch of a male. At about 85°F. the average male probably has two broods per month. The young grow rapidly and mature within two to three months. At least three generations are produced a year. Few individuals attain the age of a year, and no evidence of two-year-old fish was found.

Many people aided in this study. In particular, I wish to thank Dr. Howard T. Odum for his encouragement and assistance, Dr. E. Lowe Pierce for the use of much of his personal equipment, Dr. Clark Hubbs for providing space in The University of Texas aquarium room, and Charlene Strawn who helped with all stages of the study and prepared the figures. Drs. W. Frank Blair, Archie F. Carr, Arnold B. Grobman, and B. B. Leavitt have offered valued suggestions.

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#### Sexual Cycle of the Male Lizard, *Anolis carolinensis*

WADE FOX

EXPERIMENTAL work with the green anole, *Anolis carolinensis* has necessitated a detailed study of the normal histology of the male reproductive system. It seems of

value to present this study because only certain phases of the reproductive phenomena of this species have been described in the literature. Hamlett (1952) has outlined the egg lay-

ing cycle of the female and both he and Gordon (1956) have established that the breeding period of this species in the vicinity of New Orleans extends from early April through August. Although Evans and Clapp (1940), Greenberg and Noble (1944) and Dessauer (1955a) have presented evidence that the male gonads undergo cyclic changes, they have not, as in the present study, attempted to follow in detail the seasonal variations in the histology of the testis and accessory sex organs.

#### METHODS

During 1954 and 1955 a total of 113 adult male *Anolis* (60–70 mm. snout-vent length) was collected in the vicinity of New Orleans, Louisiana. The sample sizes and dates of sacrifice are given in Table I. The animals were starved for three to four days after capture, then weighed, measured, and killed with ether. The left testis was weighed on a torsion balance; the right testis, kidney, epididymis, and ductus deferens were fixed in Bouin's solution, embedded in paraffin, sectioned at 10  $\mu$  and stained with Harris' hematoxylin and eosin. Measurements of tubules and cells were made with an ocular micrometer. To aid in the study of the interstitial cells a few testes were treated with osmic acid for the detection of lipid granules or with 2,4-dinitrophenylhydrazine (Pollock, 1942) for the detection of ketosteroids.

#### THE GONADS

**Testis weight.** The annual cycle of testis weight, as determined in the present study, duplicates that described for *Anolis* by Dessauer (1955a). The curve in Fig. 1 is based on 198 individuals collected in 20 different samples throughout the year. *Anolis* testes undergo much of their growth during the winter. The peak weight occurs in April, although they are quite large from March through May. Although Dessauer reported a pair of testes weighing 130 mg., the heaviest single gonad in the present series weighed only 55 mg.

A gradual, but marked decrease in gonad weight occurs through June, July and August. Regression is complete in late September and early October, at which time single gonads weigh as little as 1.5 mg. The period of testicular atrophy is very brief, however, and a new cycle of weight gain commences almost immediately. Considerable variation in testis weight occurs in each sample (Table I). The ranges are smallest during the period of tes-

ticular collapse; they become increasingly larger throughout the winter and spring.

**Seminiferous tubules.** The seminiferous tubules increase steadily in diameter from October through April and are maintained at near maximum size from April until the middle of June (Fig. 1). Early in the period of maximum development the tubules are very crowded, the intertubular spaces are consequently reduced, the lumina of the tubules are invaded by tall columns of spermatids. By June the intertubular spaces are more conspicuous and the tubule lumina have enlarged as a result of a decrease in the number of rows of germ cells. The seminiferous tubules shrink markedly during July and August. In September the tubules are of

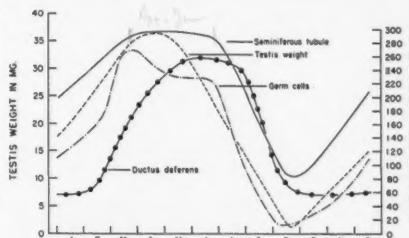


Fig. 1. Annual cyclic variations of testis and ductus deferens. The curve showing the relative abundance of germ cells was obtained by multiplying the average seminiferous tubule circumference by the average number of germ cell layers per tubule cross section. Test counts indicate that this method affords a rough index of the relative abundance of germ cells.

minimum size and tend to collapse instead of maintaining a circular cross section, thereby filling in the intertubular spaces. During the period of terminal evacuation and reorganization of the germ cells the Sertoli syncytium remains as a thin tube or ring around the periphery of the tubule. In this respect *Anolis* differs from the garter snake in which the syncytium fills the lumen of the tubule at this stage (Fox, 1952). Usually only one row of spermatogonia and the Sertoli nuclei are embedded within the ring of syncytium. The Sertoli nuclei, as in the garter snake, move away from the basement membrane, orient so that their long axis is perpendicular to it, and become less compressed and nearly vesicular. When the new cycle of cell division begins in late September and October, the Sertoli nuclei again become flattened against the basement membrane and remain there throughout the entire period of active spermatogenesis.

*Germ cells.* Spermatogenesis takes place throughout most of the year in *Anolis*, ceasing only during the latter part of August and September. For each individual lizard, however, the period of spermatogenic inactivity must be very short. In September some individuals are entering upon a new cycle of spermatogonial mitoses whereas

maturity division figures are conspicuous, but mature sperm are rare and not characteristic of this period. Since all stages continue dividing or maturing in December the primary spermatocytes tend to outnumber the spermatogonia and a few spermatozoa appear in the lumina. This trend of development continues during January and February and

TABLE I

Date	No.	Gonad		Ductus Epididymidis		Ductus Deferens		Sexual Segment	
		Left Testis Weight mg.	Seminiferous Tubule Diameter $\mu$	Diameter $\mu$	Epithelial Height $\mu$	Diameter $\mu$	Epithelial Height $\mu$	Diameter $\mu$	Epithelial Height $\mu$
March 15	12	34.3 $\pm$ 6.9 <sup>1</sup> 26-50 <sup>2</sup>	283 $\pm$ 31 230-350	111 $\pm$ 30 48-147	23.5 $\pm$ 6.7 16-40	152 $\pm$ 26 105-190	23.5 $\pm$ 7.4 12-28	85 $\pm$ 28 51-130	29.4 $\pm$ 8.9 19-48
April 29	7	36.4 $\pm$ 7.2 22-55	305 $\pm$ 28 260-350	159 $\pm$ 25 96-190	30.2 $\pm$ 7.9 22-41	219 $\pm$ 54 154-300	18.3 $\pm$ 5.7 12-25	115 $\pm$ 28 73-160	40.8 $\pm$ 12.4 22-64
May 15	6	34.6 $\pm$ 4.4 28-44	286 $\pm$ 23 290-340	183 $\pm$ 32 160-240	23.3 $\pm$ 5.0 19-32	249 $\pm$ 49 190-300	17.2 $\pm$ 4.4 13-25	135 $\pm$ 12 112-154	48.7 $\pm$ 11.4 35-67
June 4	9	27.7 $\pm$ 4.4 21-35	271 $\pm$ 26 240-330	187 $\pm$ 29 140-230	27.3 $\pm$ 4.4 22-32	227 $\pm$ 34 176-331	20.1 $\pm$ 3.9 16-28	130 $\pm$ 22 108-160	46.0 $\pm$ 8.9 35-61
June 17	6	23.7 $\pm$ 5.6 16-32	300 $\pm$ 13 280-310	203 $\pm$ 15 192-225	23.0 $\pm$ 1.6 21-25	236 $\pm$ 28 190-260	16.6 $\pm$ 1.3 16-19	112 $\pm$ 22 124-176	51.8 $\pm$ 7.6 45-64
July 5	5	23.4 $\pm$ 5.5 18-31	266 $\pm$ 29 222-304	198 $\pm$ 21 175-225	27.1 $\pm$ 7.0 19-35	236 $\pm$ 39 200-300	15.6 $\pm$ 0.3 14-16	132 $\pm$ 8 120-145	49.2 $\pm$ 1.7 48-51
July 14	9	23.5 $\pm$ 5.0 17-33	242 $\pm$ 37 180-320	140 <sup>3</sup> 20*	20*	202 $\pm$ 28 150-240	17.4 $\pm$ 2.3 16-23	114 $\pm$ 12 100-130	33.9 $\pm$ 6.8 25-44
August 7	9	18.0 $\pm$ 2.7 14-21	235 $\pm$ 31 180-280	143 $\pm$ 38 58-190	22.0 $\pm$ 5.0 13-28	258 $\pm$ 40 200-300	16.0 $\pm$ 2.0 13-19	106 $\pm$ 30 61-145	32.8 $\pm$ 10.3 19-48
August 21	6	9.17 $\pm$ 4.5 3-17	151 $\pm$ 36 96-200	131 $\pm$ 38 70-180	20.4 $\pm$ 5.7 13-25	152 $\pm$ 28 112-190	15.7 $\pm$ 3.5 12-22	80 $\pm$ 23 45-112	24.9 $\pm$ 7.9 16-35
September 22	11	2.25 $\pm$ 0.7 1.5-4	83 $\pm$ 18 55-112	67 $\pm$ 24 48-99	17.1 $\pm$ 3.5 12-22	60 $\pm$ 19 38-85	14.4 $\pm$ 2.5 11-19	50 $\pm$ 6 41-64	14.9 $\pm$ 2.4 12-19
October 20	6	5.0 $\pm$ 0.6 4-6	109 $\pm$ 23 75-135	74 $\pm$ 21 54-102	16.4 $\pm$ 4.2 12-22	60 $\pm$ 12 45-70	17.8 $\pm$ 1.6 16-19	55 $\pm$ 13 40-70	17.3 $\pm$ 2.9 12-19
November 15	3	7.3 $\pm$ 1.5 6-10	144 $\pm$ 22 110-190	70 <sup>4</sup> 20*	16*	56 $\pm$ 12 45-76	16.3 $\pm$ 4.4 9-22	59 $\pm$ 16 38-76	18.5 $\pm$ 5.7 13-28
December 10	4	13.5 $\pm$ 3.5 6-19	200 $\pm$ 8 190-210	60 $\pm$ 8 51-70	14.5 $\pm$ 1.7 13-16	61 $\pm$ 7 54-70	17.0 $\pm$ 3.2 13-20	46 $\pm$ 2 45-48	16.0 $\pm$ 2.5 13-19
January 13	6	19.8 $\pm$ 5.0 13-26	222 $\pm$ 16 205-240	75 $\pm$ 21 55-112	15.2 $\pm$ 4.8 9-20	62 $\pm$ 14 50-74	15.4 $\pm$ 4.2 10-20	48 $\pm$ 8 35-60	16.7 $\pm$ 2.7 13-20
January 31	7	23.4 $\pm$ 4.5 17-33	217 $\pm$ 36 160-270	72 $\pm$ 18 48-102	15.5 $\pm$ 4.0 12-23	52 $\pm$ 6 48-61	16.0 $\pm$ 1.9 14-19	53 $\pm$ 9 38-64	18.7 $\pm$ 2.8 15-22
February 23	7	28.6 $\pm$ 4.5 25-34	251 $\pm$ 30 200-290	77 $\pm$ 12 61-99	16.0 $\pm$ 3.7 13-22	83 $\pm$ 17 64-99	13.8 $\pm$ 1.7 12-16	57 $\pm$ 13 38-80	17.5 $\pm$ 2.3 13-20

<sup>1</sup> Mean and standard deviation.

<sup>2</sup> Range.

<sup>3</sup> Measurement based on only one or two specimens.

other specimens are still dispelling the disrupted spermatocytes and spermatids of the previous annual cycle.

Spermatogonia are the most abundant from of germ cell present in the seminiferous tubule during October. At this time, however, a few new primary spermatocytes and occasional secondary spermatocytes and spermatids can be found. By mid-November, due largely to spermatogonial mitoses, there are as many as two to seven layers of germ cells per tubule cross section. First and second

secondary spermatocytes become the most numerous cell type. Spermiogenesis stages are very conspicuous and mature spermatozoa appear in the lumina of most, although not all, tubules at this time.

The greatest number of germ cells are found in tubules of animals collected in March (Fig. 1). All cell types are abundant, but the various stages of spermiogenesis predominate. Considerable numbers of spermatozoa are leaving the testis by mid-March. Of the 15 layers of germ cells characteristic

of tubules five of the spermatogonia are zero to two, and up to five of the spermatocytes are advanced through their total number in section in March (Fig. 2). Numerous spermatocytes are few as one layer in January, chiefly of advanced matogonia. In this month, towards the end, others are in the to one or two layers of tubules. By the end of the month, to one or two layers of tubules, animals, are occasional. *Inter-* fixed in H. and eosinophiles, the inter- apparently do not a fixation but many cells are treated intertubularly in the birds, relatively few in the period of a year, an average of one cell per one-third of the testis. *Anolis* is a lizard (S. to find a lizard and published hydrazine strate or cells in a

of tubular cross sections at this time, four to five of the peripheral ones are composed of spermatogonia and primary spermatocytes, zero to three of secondary spermatocytes, two to five of early spermatids, and four to six of advanced spermatids.

Spermatogenesis continues very actively through April, May and June, although the total number of germ cells per tubule cross section is lower during these months than in March (Fig. 1). Spermatids are the most numerous cell type, spermatogonia and primary spermatocytes being gradually reduced to as few as one or two layers of cells. The number of layers of cells drops to around nine or ten in July and the tubular content consists chiefly of about equal numbers of early and advanced spermatids. In early August spermatogonial divisions no longer occur. During this month spermatogenesis continues towards completion in some lizards, while in others all germ cells other than the spermatogonia are being eliminated from the tubules. By the end of August the tubular contents of most individuals have been reduced to one or two layers of spermatogonia. Primary spermatocytes are rare or absent in these animals, but spermatogonial divisions are occasionally seen.

*Interstitial cells.* Sections of *Anolis* testes fixed in Bouin's solution and stained with H. and E. reveal conspicuously vacuolated, eosinophilic cells with small round nuclei in the intertubular spaces. These cells, which apparently are the functional interstitial cells, do not appear vacuolated after osmic acid fixation but contain a few black droplets and many clear refractive granules. In sections treated with 2,4-dinitrophenylhydrazine the intertubular cells stain a pale yellow suggesting the presence of a steroid. Compared to birds, mammals and snakes, *Anolis* has relatively few interstitial cells. Even during the period of maximum abundance there are, on an average, only three or four hypertrophied cells per intertubular space in fewer than one-third of the spaces. The incidence in *Anolis* is higher, however, than in the fence lizard (*Sceloporus*). Altland (1941) was unable to find interstitial cells in the eastern fence lizard and O. P. Pearson and W. Fox (unpublished data), using the 2,4-dinitrophenylhydrazine technique, were able to demonstrate only a few yellow staining interstitial cells in the western fence lizard.

Although the interstitial cells are highly variable in size and shape at all times, there is a marked seasonal fluctuation in cell size

and in the abundance of hypertrophied, secretory appearing cells. The annual fluctuation in cell size is illustrated in Fig. 2. The values from which this curve is derived represent the average cross sectional area of interstitial cells within each sample. The longest and shortest axes of three to five randomly selected cells from each individual were measured and the area of each cell was calculated by the formula for the area of an ellipse,  $A = \pi ab$ .

The relative abundance of large secretory interstitial cells appears to parallel roughly the curve for cell size. Only a few small cells are found between the crowded tubules in January. They enlarge and become more abundant from February through June. In July the tubules are less closely pressed together and the interstitial cells are larger and

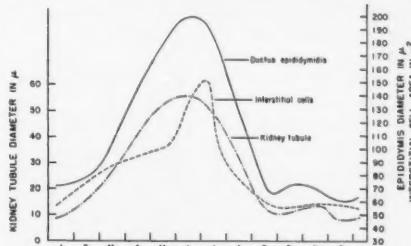


Fig. 2. Cyclic variations of ductus epididymidis, sexual segment of the kidney and interstitial cells of the testis.

more conspicuous than at any other period of the year. The extremely high values recorded for cell size during July need not necessarily reflect a sudden spurt of secretory activity. Part of the apparent growth of the interstitial cells may have been merely a passive expansion due to a decrease in pressure from the surrounding tubules; possibly, although no mitotic figures were seen, it represents a pre-mitotic enlargement; or, since at this time the cells adhere closely and cell boundaries are difficult to determine with accuracy, there may have been occasional erroneous measurements.

During August and September the vacuolated eosinophilic cells become smaller and scarce and can not be distinguished from the fibroblasts which are scattered loosely through the intertubular spaces. Throughout October, November and December functional interstitial cells are either rare or absent and, like the winter testes of passerine birds, the intertubular spaces are filled chiefly by cells resembling fibroblasts.

## ACCESSORY SEX ORGANS

*Sexual segment of the kidney.* *Anolis*, like other squamatic reptiles undergoes a marked seasonal hypertrophy of a portion of the uriniferous tubules which has been named the sexual segment by Regaud and Policard (1903). This hypertrophy is the most striking histological change which occurs in any of the accessory sex organs. As in the lizard *Takydromus* (Takewaki and Fukuda, 1935) the sexual segment of *Anolis* includes the uriniferous collecting ducts and at least that portion of the ureter which is embedded within the kidney (Pl. I B and C); the termination of the ureter and the cloaca were not examined histologically in the present study. The uriniferous collecting ducts include: 1) a series of large secondary collecting ducts which run somewhat transversely from medial to lateral across the ventral surface of the kidney (Pl. I B and C) and empty into the ureter at intervals of 300 to 500  $\mu$ ; 2) units of six to eight smaller primary collecting ducts (Pl. I B and C) which drain the dorso-medial portion of the kidney and which run from dorsal to ventral to empty into one of the above transverse secondary ducts; 3) additional large, unbranched collecting ducts (Pl. I C) which drain the dorso-lateral portion of the kidney and enter the ureter independently.

Hypertrophy of the sexual segment not only begins in the ureter, but the epithelium of this organ ultimately achieves the greatest height. As the breeding season approaches, secretory hypertrophy extends from the ureter to the secondary collecting ducts which become the second largest secretory segment. The primary collecting tubules are the last to enlarge and never attain the maximum tubule diameters or epithelial heights of the secondary collecting tubules or ureter. The maximum figures presented for the sexual segment in Table I represent measurements of the secondary collecting ducts near the ureter, while the minimum figures were obtained from the primary collecting ducts. The hypertrophy of the distal segments of the large unbranched collecting ducts roughly parallels that of the secondary collecting ducts; their proximal segments correspond to the primary ducts.

The average tubule diameter (Fig. 2) and epithelial height (Table I) of the sexual segment achieve a three-fold hypertrophy during the breeding season. During August the secretory tubules undergo considerable reduc-

tion in size, and lose the highly secretory characteristics which were present at the beginning of the month. Epithelial height declines to a minimum in the fall and winter (Pl. I A). Neither the slight rise in cell height recorded in October and November, nor the subsequent decline recorded in December and January prove to be of statistical significance ( $P = .07$  and .10 respectively). The epithelium does not regain a highly secretory appearance until February or March. During the latter month the epithelium of the secondary collecting tubules and ureter nearly doubles in height and the apical halves of the cells become filled with eosinophilic granules. During the next few months cellular enlargement and evidences of secretion extend proximally along the primary collecting ducts and distally along the ureter. The apical two-thirds of the cells contain eosinophilic granules (Pl. I B) which appear to be pushing into the lumen. Moreover, the lumen is irregularly filled with eosinophilic masses of similar appearance. In June, at the height of development, the hypertrophied segment extends extensively over the ventral surface of the kidney, deep into the interior, and frequently reaches the dorsal surface (Pl. I C). At this time the kidneys are about twice their winter size.

*Epididymis.* The seminiferous tubules communicate with two to four ductuli efferentes, the epithelium of which becomes increasingly flattened distally. These thin walled tubules course in a wide arc through the collagen layers comprising the tunica albuginea. Within a few hundred micra each ductulus efferens communicates with two to five ductuli epididymidis. A few of the ductuli epididymidis are short and end in cul-de-sacs (ductuli aberrantes), but the remainder pursue an irregular convoluted course for several millimeters before entering the ductus epididymidis.

The ductuli epididymidis are lined by cuboidal cells with thick stereocilia. The cytoplasm is weakly eosinophilic and without distinct secretory granules. The middle segments of the ductuli are very narrow, but both diameter and epithelial height increase as the ductus epididymidis is approached. No cyclic changes in epithelial height or secretory activity were detected in the proximal or middle portions, but the distal ends of the ductuli undergo annual changes which parallel those of the ductus epididymidis.

The epithelium of the ductus epididymidis

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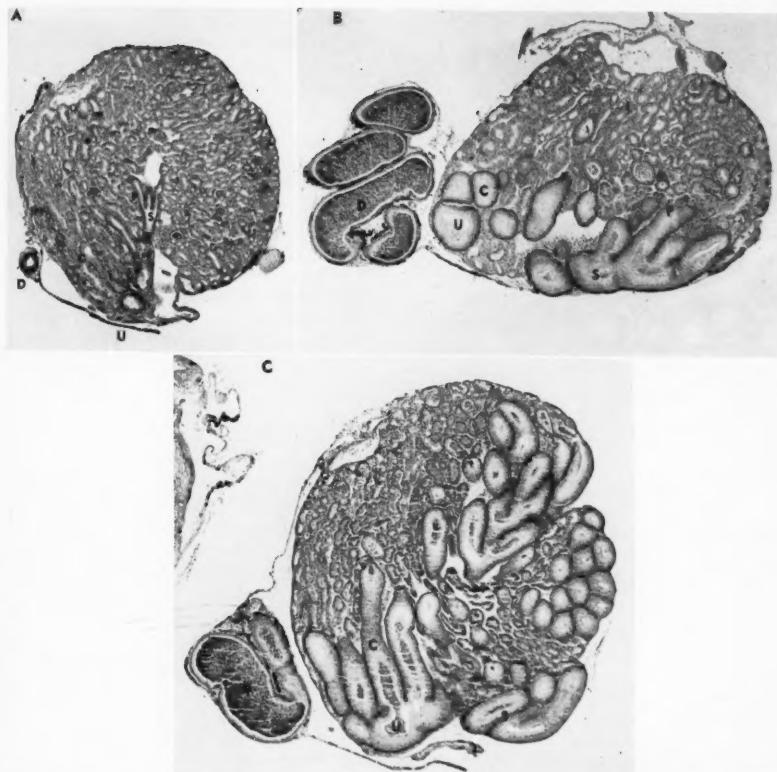


Plate I. Cross sections of kidney and ductus deferens of *Anolis carolinensis*. 32X. Dorsal surface of kidney above, lateral surface on the left. A. Fall and winter. Sexual segment atrophic; ductus deferens small, pseudostratified and empty. B. Spring. Hypertrophy of sexual segment involves the ureter, secondary and distal primary collecting ducts; ductus deferens dilated, greatly convoluted and filled with sperm. C. Summer. Ureter and all collecting ducts hypertrophied; ductus deferens dilated, convoluted and filled with sperm. U = ureter, P = primary collecting ducts, S = secondary collecting duct, C = unbranched collecting ducts, D = ductus deferens.

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increases in height during March and April (Table I) and remains at nearly twice its winter height throughout May and June. These columnar cells are packed with secretion granules and the apice appear slightly eosinophilic when stained with H. and E. Simultaneously, the diameter of the ductus undergoes a threefold increase (Fig. 2) and becomes much more convoluted. Epithelial height and tubule diameter decrease gradually during July, August, September and October. Minimum measurements were recorded in December. A slow increase in size is detectable in January and February. Only a few transitory sperm are seen in the ductuli at this time, but by the end of March storage of sperm is well underway in the ductus epididymidis. Peak sperm storage occurs in June and early July. The ductus epididymidis remains well filled with sperm until early August, but by the end of this month sperm are replaced with the degenerating debris which has resulted from incomplete spermatogenesis. In the September sample most of the ductus epididymidis are empty.

*Ductus deferens.* Measurements of epithelial height fail to present a true picture of the marked seasonal hypertrophy of the ductus deferens. The annual fluctuation of the ductus diameter indicates the timing of the seasonal cycle, but does not measure the increase in length. The latter must be considerable for the slightly wavy ductus of the winter months (Pl. I A) is converted into a highly convoluted organ during the breeding season (Pl. I B).

As in other accessory sex organs, the height of the epithelium begins to increase in March. Later, as the duct fills with sperm, the epithelium appears to be stretched thinner. During the breeding period the cytoplasm is basophilic and the apical portions of the cells are crowded with tiny refractive granules. Maximum distention and convolution occur from May through July (Fig. 1). During this time, the epithelium is usually cuboidal. In August the cells become slightly eosinophilic and by September the entire cytoplasm has a pale vacuolated appearance with little or no evidence of secretion. The much reduced lumen contains only the debris resulting from the disruption of spermatogenesis. The lumen of the ductus deferens remains empty of cells or sperm until late January. During this atrophic period the columnar epithelium becomes slightly folded and appears pseudostratified; the cytoplasm is agranular. Gran-

ules are first observed in February and are prevalent by March.

#### IMMATURE MALE LIZARDS

A number of lizards measuring less than 60 mm. in snout-vent length were examined during the course of this study. Animals that were between 50 and 60 mm. and apparently completing their first year, had testes which underwent considerable hypertrophy, although their gonads never grew as large as those of the adults. In any sample of lizards collected during the breeding season, there was a very significant correlation between testis weight and body weight or length. The regression coefficients of testis weight on body length and body weight for a June sample of 14 animals (55 to 69 mm. snout-vent length; 2.5 to 5.7 gm.) were 1.55 mg./mm. and 7.57 mg./gm. respectively.

Microscopic examination of the testes revealed that lizards between 50 and 60 mm. were undergoing spermatogenesis at a rate comparable to the adults. In those above 55 mm. the sexual segment of the kidney was greatly hypertrophied and apparently secretory during the breeding season. These animals appeared to be sexually mature although there is some indication that males of this size are not successful in mating. Males measuring approximately 51 to 53 mm. had only a minor hypertrophy of the sexual segment and little evidence of secretion. For this reason, I do not feel that they should be regarded as sexually mature despite their active gonads. Since young *Anolis* have a rapid growth rate (Gordon, 1956), it is possible that males which appear to just fall short of full sexual maturity at the beginning of a breeding period may achieve this status before the period is over. Most individuals between 42 and 50 mm. snout-vent length carry on an appreciable amount of spermatogenesis in the spring. However, since this is far less than that of the larger animals, and the sexual segment shows little or no hypertrophy, their immaturity can hardly be questioned.

#### DISCUSSION AND SUMMARY

The seasonal activity of the reproductive organs of male *Anolis carolinensis* is remarkable in several respects. The most unusual feature is the continued activity of both the testes and accessory sex organs through the summer months. In most lizards the breeding season is limited to a relatively short period

in the spring and the accessory sex organs are hypertrophied only during this time. In *Anolis*, the breeding period extends from April to August (Hamlett, 1952; Gordon, 1956). Consequently, although *Anolis* resembles other lizards in that it has considerable spermatogenic activity during the winter, it is unusual in that this activity does not terminate abruptly in April, May or June but continues into August. The sperm produced during the summer months are not stored

didymidis, and ductus deferens) parallel very closely the hypertrophy of the interstitial cells (Figs. 1 and 2). Possibly the size of the ductus deferens is also influenced by the quantity of sperm in the lumen (Fig. 1, Pl. I). The spermatogenic cycle appears to be independent of the interstitial cell cycle.

In view of the considerable research on the environmental regulation of annual rhythms of vertebrates, it is interesting to note that spermatogenesis in *Anolis* is initiated during

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TABLE II

	I (November)	II (Dec.-Jan.)	III (March-May)	IV (June-July)	V (Late August)	VI (September)
Testis weight	7 mg	20 mg	34 mg	25 mg	10 mg	2 mg
Seminiferous tubule	145 $\mu$	210 $\mu$	290 $\mu$	270 $\mu$	150 $\mu$	83 $\mu$
Rows of germ cells	2-7	5-14	10-24	6-22	1-10	1-2
Most advanced stage	Spermatocytes or spermatids	Late spermatids	Sperm	Sperm	Sperm	Loose cells debris
Most abundant stage	Spermatogonia	Spermatocytes	Spermatids	Spermatids	Late spermatids	Spermatogonia
Rows of spermatogonia	2-3	2-3	1-3	0-2	0-1	1
Rows of primary Spermatocytes	1-2	2-3	3-5	0-3	0-2	0
Interstitial cells	Few small	Abundant medium	Abundant large	Abundant large	Few small	Rare small
Sexual Segment	Epithelial height Tubule diameter Cytoplasm	18 $\mu$ 55 $\mu$ Basophilic granular	18 $\mu$ 55 $\mu$ Apical $\frac{1}{3}$ eosinophilic near ureter	40 $\mu$ 120 $\mu$ Apical $\frac{1}{2}$ eosinophilic ureter- middle	50 $\mu$ 135 $\mu$ Apical $\frac{2}{3}$ eosinophilic throughout	25 $\mu$ 80 $\mu$ Basophilic vacuolated
Ductus Epididymidis	Epithelial height Tubule diameter Content	15 $\mu$ 70 $\mu$ Empty	15 $\mu$ 75 $\mu$ Empty or few sperm	28 $\mu$ 160 $\mu$ Many sperm	24 $\mu$ 190 $\mu$ Many sperm	20 $\mu$ 130 $\mu$ Sperm, debris or empty
	Cytoplasm	Agranular	Granular	Granular	Granular or vacuolated	Vacuolated
Ductus Deferens	Epithelial height Tubule diameter Content	16 $\mu$ 56 $\mu$ Empty	16 $\mu$ 60 $\mu$ Agranular	20 $\mu$ 215 $\mu$ Sperm	17 $\mu$ 230 $\mu$ Granular	16 $\mu$ 150 $\mu$ Sperm Granular
	Cytoplasm	Agranular	Granular	Granular	Granular	Empty Agranular

for future fall or spring mating periods, as is the case in most snakes, but are utilized only in the current breeding period.

August appears to be the month for drastic changes in *Anolis*. The testes collapse, the seminiferous tubules are evacuated, germ cell divisions cease, and interstitial cells and accessory sex organs atrophy. While the reproductive structures are regressing, appetite is high and fat and glycogen storage increase tremendously (Dessauer, 1955b).

The endocrine relationships suggested by the histology of the reproductive organs conform to the typical vertebrate pattern. Seasonal hypertrophy of the accessory sex organs (sexual segment of the kidney, ductus epi-

a period of decreasing day length and continues throughout the period of increasing day length. On the other hand, the hypertrophy of the accessory sex organs coincides perfectly with the seasonal increase in day length. The progress of spermatogenesis does not appear to be altered by the extremes of temperature which occur in either the coolest or warmest months of the year.

The seasonal fluctuations of the male reproductive system of *Anolis carolinensis* in New Orleans are summarized in Table II. The intent in presenting this table is to establish arbitrary stages which depict distinct phases of the normal cycle. Since the reproductive status of an experimental, control

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or freshly captured lizard can be expressed clearly and concisely by assigning it to one of the six stages, the table can be used to replace extensive, and thereby confusing, descriptions of histological findings and mensural data. The measurements presented for each stage take into consideration variation within stages and do not represent the arithmetic means of the samples in Table I.

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## A Taxonomic Study of the Ratsnakes

VI. Validation of the Genera *Gonyosoma* Wagler and *Elaphe* Fitzinger

HERNDON G. DOWLING

A PROBLEM in nomenclature that has long lain dormant has recently been brought to the attention of the International Commission on Zoological Nomenclature by Robert Mertens (1956). This problem was created by the action of Stejneger (1907: 443-45) who demonstrated that the Linnaean name *Coluber* had been misapplied to the ratsnakes (*sensu latu*). He, however, chose the name *Elaphe* Fitzinger (1833) rather than the oldest available name for this group, *Gonyosoma* Wagler (1828). As recently pointed out by James A. Peters (1956), this error in selection of the proper generic name was demonstrated long ago by Fejervary (1923: 169). However, this paper appears to have been steadfastly avoided by workers in both Europe and America. More recently Malcolm Smith (1943: 141) again suggested that, "Gonyosoma therefore should stand as the name of the genus," but did not utilize it in his work since "Its limits, however, are not yet clearly de-

fined, and fresh work upon it will probably result in further changes in nomenclature."

Mertens (1956) referring to Smith's statement, has proposed to avoid the substitution of the little known name *Gonyosoma* for the well-established name *Elaphe* by requesting the Commission to suppress the former. Peters (1956) has opposed this action on the basis that it has not been demonstrated that the type species of these two nominal genera are actually congeneric, and that Mertens' proposal would in effect, "give the surface appearance of solution to a problem that is essentially biological in nature." He would instead "Recommend the usage of standard procedures in determination of the proper name to be used for the genus as currently defined."

Although each of these proposals is attempting to stabilize current and future nomenclature in a different way, both have certain undesirable features. Thus while

Mertens' proposal would stabilize the name *Elaphe* for the present, it might also (as pointed out by Peters) open the way for a new generic description for any Asiatic species now referable to *Gonyosoma*. In no case, of course, could it "stabilize" the name *Elaphe* for other than its type species. Similarly, while Peters' proposal would leave the name *Gonyosoma* available for the Asiatic (and possibly other) species, it also would require the immediate (and perhaps only temporary) application of this name to the European and North American species now known as *Elaphe*.<sup>1</sup> The present study was initiated to investigate the biological aspects of the problem: the actual degree of relationship between the type species of the two nominal genera.

## HISTORICAL SKETCH

The problem probably would never have arisen if the taxonomic treatment of the European and Asiatic species had followed the same trend as that of the North American forms. Boulenger (1894: 26) was apparently the last worker to attempt a definition of the entire ratsnake group, which he called *Coluber* [*non* Linnaeus], on a worldwide basis. He defined this group as: "Maxillary teeth 12 to 22, subequal in size; anterior mandibular teeth longest. Head distinct from neck, elongate; eye moderate or rather large, with round pupil; loreal sometimes absent. Body elongate, cylindrical or feebly compressed; scales smooth or keeled, with apical pits, in 15 to 35 rows; ventrals rounded or angulate laterally. Tail moderate or long; subcaudals in two rows."

Cope (1900: 788) criticised this overly comprehensive grouping and recognized five American genera therein, saying, "An examination of the penial characters leads me to the opinion that . . . [Boulenger's *Coluber*] is a series of genera rather than a single genus." American workers readily accepted Cope's restricted genera and most of the groups recognized by him were carried over by Stejneger and Barbour (1917) into their first *Check List of North American Amphibians and Reptiles*, although many of the names were changed as a consequence of the newly established (1901) *International Rules of Zoological Nomenclature*. Thus of sixteen American species of "Coluber" [= *Elaphe* *auct.*]

recognized by Boulenger, only seven were retained in this genus by Cope, the others being referred to those diverse genera currently recognized as *Arizona*, *Pituophis* and *Spilotes*.

The taxonomic treatment of Eurasian snakes has been far different. Few European workers recognized the applicability of Cope's criticisms to Boulenger's Old World generic groups. For many years these were overlooked just as was Stejneger's (1907: 443) later demonstration of the misapplication of the name *Coluber* Linnaeus. A survey of the most recent regional works available to me, for Indo-China (Bourret, 1936), Japan (Maki, 1931), Europe (Mertens and Müller, 1940), China (Pope, 1935), and India (Smith, 1943), indicates that the twenty-nine Old World species listed as *Coluber* by Boulenger have been transferred *in toto* to *Elaphe* without any attempt at more restricted generic definition. American workers as well have tended to use Boulenger's generic categories in dealing with Eurasian species and the few exceptions (e.g., Schmidt, 1925: 4; Taylor, 1922: 152) have not attempted to define their restricted categories except on regional bases. Most workers seem to agree with Pope (1935: 277) who said, "Although without doubt the species of *Elaphe* as generally understood are too varied to be included in a single genus, the problem of properly dividing them is a major task because there are apparently no sharp lines of demarcation."

## PROCEDURE AND FINDINGS

Series of snakes of the type species of the two nominal genera were studied (see list of specimens) and their characteristics compared with one another and with those of other European and North American species which are currently recognized in the genus *Elaphe*. The type species are *Gonyosoma oxycephalum* Boie and *Elaphe quatuorlineata* Lacépède, whose descriptions follow.

### **Gonynosoma oxycephalum** Boie

*G. oxycephalum* is a large racer-like tree-snake of southeastern Asia which is green in coloration and possesses an unusually long muzzle.

**BODY PROPORTIONS**—The largest specimen (of 15) has a body length of about 1490 mm. and an incomplete tail. Many individuals are so twisted as to give only approximate measurements and, as in most long-tailed snakes, usually only the subadult individuals have undoubtedly complete tails. One adult, a fe-

<sup>1</sup> After the present paper was submitted for publication both of these workers revised their proposals to avoid the more undesirable aspects.

male (US) measured with length 11.5 (posterior eye length) margin of eye proportion percent of body, eye, muzzle 3.5, other ad. proportion, portion of num of percent young-of-

**COLOR.** above, the black; yellow streak along through lowish brown "bands" many of slate color preservative 50 years) which is a mens of *Leptostomodrys*). In there is a n

separating individuals from individuals *floweri*" (Vinton 1970: 105) as "light bars on the back. . . ."

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small in number, long as it is irregular, 3 or 4 in a row may have 3 or 4 scales to 11; the specimens with labia 8 present,

male (USNM 38539), can be completely measured with some degree of accuracy: Body length 1182 mm.; tail length 400; head length (posterior edge of jaw to tip of snout) 40; eye length 5.7; muzzle length (anterior margin of eye to tip of snout) 14.8. Some of the proportions indicated are: tail length 33.8 percent of body, head length 3.4 percent of body, eye 14.3 percent of head length, and muzzle 37.0 percent of head. None of the other adult snakes varies much from these proportions, but the young tend to have proportionately larger heads and eyes; a maximum of 5.9 percent of body length and 18.3 percent of head length respectively in one young-of-the-year.

**COLORATION AND PATTERN**—“Bright green above, the scales usually finely edged with black; yellow or pale green below; a blackish streak along each side of the head, passing through the eye [see Fig. 1]; tail usually yellowish brown, with or without vermilion bands” (Boulenger, 1912: 144). Although many of the specimens examined by me are slate colored (probably as a result of formalin preservation), some retain (after more than 50 years) the distinctive bright blue color which is also found in alcohol-preserved specimens of North American greensnakes (*Ophrydrys*). In those specimens having brown tails, there is a sharp division at the cloacal opening with a narrow irregular light (yellow?) line

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separating the two colors. Not all green individuals have the brown tail, and some individuals have been described (“*Coluber floweri*” Werner) which lack the green coloration completely, being brown throughout. The young are described (De Rooij, 1917: 105) as “olive-brown with narrow oblique light bars on the posterior part of the back . . .”

**SCUTELLATION**—The head shields are normal in number and arrangement for colubrid snakes (see Table I for various quantitative characters). The loreal is at least twice as long as it is high (Fig. 1). The temporals are irregular, usually 1 or 2 in the first row and 3 or 4 in the second. A third, highly irregular row may be distinguishable; it usually has 3 or 4 scales. The supralabials range from 7 to 11; the last one is extremely long in those specimens with only 7. The eye is in contact with labials V and VI when there are 7 or 8 present, and usually VI and VII when there

are 9 or 10. Three labials, VII, VIII, and IX, contact the eye in the single specimen with 11 supralabials on one side. The posterior genial plates are very small, being less than one half the length of the anterior, and are not separated from one another by other scales.

The dorsal scales bear two extremely faint apical pits which are elongate and near the distal end of the scale; the length of pit is greater than its distance from the tip. The dorsals at midbody are smooth through row IX at least, and may be smooth throughout. The keels are low and are distinguishable only with difficulty. There is no increase in keeling posteriorly, those specimens with smooth scales at midbody also have them smooth above the cloacal opening, while those with some dorsal rows (usually 3 or 5) keeled at midbody have the same rows keeled posteriorly. No sexual differences are apparent, neither does there appear to be any correlation of increased keeling with size; some of the small individuals (body length, 592 mm.) have five rows keeled while some of the large ones (body length, 1370) appear perfectly smooth. The dorsal scale rows usually number 25 + 25 + 17 but there is considerable variation (Table I). The scale reduction formula (see Dowling, 1951b, for explanation) of a typical individual from Java (USNM 43283) is:

Although the total number of rows varies, all specimens demonstrate the same kinds of reductions: one involving rows III and IV, all others involving the paravertebral rows. The reduction in rows III and IV does not appear to be highly correlated in longitudinal position with the others and may be involved in the reduction from 27 to 25, 25 to 23, or 23 to 21. It is always only a short distance posterior to the midbody, however. In the single individual showing an addition posterior to the neck region, the row added is also paravertebral.

The number of ventrals is a sexually dimorphic character with the males having some ten fewer than the females; the anal plate is divided in all specimens; the number of paired subcaudals shows no obvious sexual difference in the few specimens with complete tails.

**HEMIPENIS**—The hemipenis extends to subcaudal XVII with its terminal retractor mus-

cle originating at the level of caudals XLII and XLIII. In general appearance the organ is spinose for its proximal two-thirds and calyculate in its distal third (Plate I-b). An oval patch of about 30 large (about 10 mm.) fleshy spines is found on the side of the hemipenis opposite the sulcus, this area extending from near the base of the organ for about two-thirds its length. A seemingly bare area adjacent to the sulcus proves upon close inspection to be dotted with tiny (about 0.5 mm.) spinules which also are found on the lips of the sulcus. Large spinules surround the base of the organ. The calyces are rather large (2-4 mm.) and irregular. They are also dotted with spinules except for a few in the most distal row. There is no indication of a distal lobe. The spiny patch and spinulose nature of the calyces are shown (rather dia-

columella is distal to this "neck" (Fig. 2). The palatine is stout, with the lateral process far back and longer than the short but heavy medial process (Fig. 2).

**VERTEBRAE**—The midthoracic vertebrae are about as high as wide, and the neural spines are longer than high. The glenoid fossa is slightly oval horizontally. The prezygapophyses have subrectangular articular surfaces; their accessory processes extend slightly beyond them and somewhat ventrally. The haemal keel is flattened and is set off from the rim of the glenoid fossa by a depression. It ends posteriorly in a sharp point which extends over the poorly-developed neck of the condylus nearly to the articulating surface of the latter. The subcentral ridges are separated from the haemal keel by deep grooves, causing the ridges to parallel roughly the keel (Fig. 3).

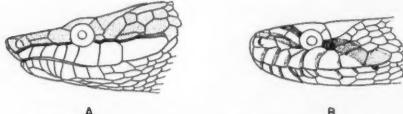


Fig. 1. Lateral views of the heads of (a) *Gonyosoma oxycephalum* and (b) *Elaphe quatuorlineata*. The elongate muzzle of *G. oxycephalum* is indicated both by the long loreal plate and the large number of supralabials anterior to the eye. The dark line passing horizontally through the eye of this species is found in no species of *Elaphe*; the head pattern in *E. quatuorlineata* is characteristic for the genus.

gramatically) by Cope (1900: pl. 15, fig. 4), but these features are not readily apparent in Smith (1943: 145, fig. 45).

**SKULL**—The skull is narrow anteriorly and posteriorly with the orbital region greatly expanded (vide Smith, 1943: 140, figs. 44-A, B, D, labeled *Elaphe radiata* [in error]). The nasals are expanded laterally and extend slightly anteriorly along their lateral borders so as to give a broad shallow anterior notch. The prefrontal is low and has an unusually long anterior projection (15 percent of skull length) which makes it longer than high. The squamosal is small (28 percent of skull length) and has a strongly developed tubercle at the anterior end of its articulation with the quadrate (Fig. 2), allowing the latter to project posteriorly although its proximal end is square. The quadrate is considerably longer than the squamosal (34 percent of skull length) and is slender except for a broad proximal articulating surface. It is almost round in cross section distal to its mid-part, and the ossified point of attachment of the

#### *Elaphe quatuorlineata* Lacépède

*E. quatuorlineata* is a moderately large, fairly thick-bodied snake of southern and central Europe, light brown in coloration with dark blotches or longitudinal stripes.

**BODY PROPORTIONS**—The largest specimen available has a body length of about 1120 mm. and an incomplete tail. All of the other available specimens also had incomplete tails and are so twisted as to make accurate body measurement impossible. The eye makes up about 13 percent of the head length in adults and the muzzle length is about 30 percent.

**COLORATION AND PATTERN**—Individuals of the typical subspecies (*E. q. quatuorlineata*) from western Europe are light brown with blackish stripes on dorsal scale rows IV-V and IX-X; those of the subspecies *E. quatuorlineata sauroimates* Pallas from eastern Europe are blotched with dark brown or black with the blotches heavily invaded with ground color so as to give a mottled effect. Both subspecies show a distinct postorbital bar which extends from the orbit posteriorly and ventrally to end on the last supralabial (Fig. 1). According to Boulenger (1894: 46) the young of both subspecies are blotched.

**SCUTELLATION**—The head shields are normal in number and arrangement for colubrid snakes (see Table I for various quantitative data). The loreal is a little longer than high. A presubocular, present under the large preocular, appears to have been separated off the anterior and dorsal edge of the fourth supralabial. The temporals are in three rows: 2 or 3 in the first row and 4 or 5 in each of the others. The supralabials are 8 or 9, with

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labials IV-V in contact with eye when 8 are present, labials V-VI when there are 9. The posterior genials are somewhat shorter (80 percent) than the anterior ones.

The dorsal scales bear two small but distinct rounded apical pits which are somewhat removed from the tip of the scale; the distance from the tip is greater than the length of the pit. Only the first two scale rows are smooth at midbody, the remaining rows being fairly weakly but distinctly keeled. The dorsal scales are usually in 25 + 25 + 19 rows, but two individuals have an irregular addition for a short distance which if ex-

**HEMIPENIS**—The hemipenis extends to sub-caudal XV, with its terminal retractor muscle originating at the level of subcaudals XLIII to XLV. Proximally the organ is naked for almost a quarter of its length, then follows a band of small spines for somewhat more than a quarter the length of the organ; this is followed by a long calyculate area which extends almost to the tip of the organ (Plate I). There are no spinules on the basal region; the spinose area is covered with about 175 small (2-3 mm.) spines; the calyculate area is set off distinctly from the spines and is made up of small (about 1 mm.), evenly dis-

TABLE I  
VARIATION OF CERTAIN QUANTITATIVE CHARACTERS IN TWO COLUBRID SNAKES

	Oculars	Temporals	Supra-labials	Infra-labials	Gulars	Dorsals	Ventrals	Caudals	Maxillary Teeth
<i>Gonyosoma oxycephalum</i>	2 + 4 [14]	2 + 4 + 6 [1]	14 [1]	24 [1]	2 [1]	23 + 23 + 15 [2]	♂♂ 230-40	♂♂ 131-45	21 [4]
	2 + 6 [1]	2 + 5 + 6 [1]	16 [1]	25 [2]	3 [10]	23 + 23 + 17 [1]	♀♀ 243-53	♀♀ 134-41	22 [3]
		2 + 6 + 6 [1]	17 [5]	26 [9]	4 [2]	25 + 23 + 15 [1]			23 [3]
		3 + 5 [1]	18 [1]	27 [1]	5 [2]	25 + 25 + 15 [2]			
		3 + 6 + 7 [1]	19 [4]	28 [1]		25 + 25 + 17 [6]			
		3 + 6 + 8 [1]	20 [1]			25 + 27 + 17 [1]			
		3 + 7 + 7 [1]	21 [1]			27 + 25 + 17 [1]			
		3 + 8 [1]							
		4 + 6 [3]							
		4 + 7 [2]							
<i>Elaeophis quatuorlineata</i>	4 + 4 [3]	4 + 8 + 10 [1]	16 [2]	21 [1]	4 [3]	24 + 25 + 19 [1]	♂♂ 204-07	?	19 [2]
		6 + 8 + 9 [1]	17 [1]	22 [2]		25 + 25 + 19 [2]	♀♀ 217	?	
		6 + 9 + 8 [1]							

Oculars, temporals, and labials are shown as both sides added. The number in brackets indicates the number of individuals having that particular character.

tended would give counts of 25 + 27 + 19. The scale reduction formula of an individual from Romania (USNM 37322) is:

$$\frac{24}{+ 6(32)} \frac{25}{- 6(117)} \frac{23}{4 + 5(130)} \frac{5 + 6(131)}{5 + 6(165)} \frac{21}{5 + 6(168)} \frac{19}{19(204)}$$

In those individuals with irregular additions anteriorly (which in no case extend more than 20 ventrals and do not reach midbody), either a sixth or a seventh row is added, then reduced. Other reductions are as shown above, with the sixth row involved in the reduction from 25 to 23 and the fifth (either 4 + 5 or 5 + 6) involved in the other two. All additions and reductions, therefore, are approximately midlateral.

The number of ventrals is a sexually dimorphic character with the males having about 10 fewer than the females; the anal plate is divided in all specimens; the subcaudals are paired. All available specimens have incomplete tails.

tributed calyculi. There are no spines or spinules in the calyculate area. The lips of the sulcus are unornamented in the basal re-

gion, spinose in the spiny region, and calyculate distally. Folds in the hemipenis near its distal end indicate that the organ would be somewhat two-lobed if everted.

**SKULL**—The skull is rather narrow posteriorly and broadest in the postorbital region. The nasals are small and together form almost a perfect circle. The prefrontal is considerably higher than long (length 57 percent of height). The squamosal is moderate in length (39 percent of skull length) and has a slightly raised articulating surface for the quadrate (Fig. 2). The latter is slightly shorter than the squamosal (38 percent of skull length), wide and flat throughout, and has an oblique proximal articulating surface (Fig.

2). The palatine is rather delicate in structure, with a short lateral process placed anterior to the midline and a much larger broad decurved medial process (Fig. 2).

**VERTEBRAE**—The midthoracic vertebrae are broad with rather low neural spines (longer than high). The glenoid fossa is horizontally oval. The accessory processes of the prezygapophyses extend only slightly beyond the suboval articular surfaces but project strongly downward. The haemal keel is well-developed and flattened, and merges imperceptibly with the rim of the glenoid fossa anteriorly. It ends posteriorly in a squarish tip somewhat anterior to the neck of the condylus. The subcentral ridges are poorly developed.

#### COMPARISON OF *Elaphe* AND *Gonyosoma*

The descriptions above clearly show that the two species differ in a large number of apparently unrelated characteristics. The question, however, is not of the distinctness of two species, but of the relations of two nominal genera. One method of determining such generic relationship is to analyze the divergence of the various included species; to determine whether any species or group of species differs from others to the extent that other recognized genera differ. Or conversely, the group may be examined to determine whether all of the species are no more differentiated than are the species of other carefully analyzed genera. Such an attempt is made here to define the level of divergence between some of the better known species of *Elaphe* and the monotypic genus *Gonyosoma*.

**Quantitative Characters**—Any belief that generic distinctions in this fairly generalized group of snakes could be established on the basis of quantitative characters is dispelled by reference to better known species. Thus *Elaphe guttata* Linnaeus of eastern North America alone completely bridges the gap in ventral numbers between *Gonyosoma oxycephalum* and *E. quatuorlineata*: specimens from New Jersey have an observed minimum number of 206 while individuals from southern Florida have as many as 241. This species also spans the apparent gap in infralabial number, with variations from 21 to 26 (both sides added) observed in the populations of the southeastern United States.

Although *G. oxycephalum* is a long-tailed snake, it is surpassed in this respect by the otherwise quite different *E. triaspis* Cope of Central America and Mexico (tail length up to 35 percent of body). The latter also ap-

proaches *G. oxycephalum* in observed number of subcaudals (up to 127 in *E. triaspis*) and the gap of three scutes will undoubtedly be bridged when larger series of either species are examined. The numbers of supralabials, temporals, and midbody scale rows broadly overlap in *G. oxycephalum* and *E. quatuorlineata*, and the low counts of posterior scale rows in the former are matched in part (17 scale rows) by *E. longissima* of southern Europe as well as by *E. obsoleta* of North America. The observed differences in numbers of maxillary teeth are bridged by both *E. triaspis* and *E. subocularis* Brown. Reference to Boulenger (1894: 29) or to other workers on Asiatic snakes indicates that while quantitative characters may be utilized in regional definitions, they are useless in defining generalized genera on a worldwide basis.

It may be noted that all of the above commonly utilized characters of scutellation and teeth have fairly broad ranges of variation within any one population of snakes. In fact they are the most highly variable characters which might be utilized in taxonomic studies of snakes. Such variable characters are admirably suited to analysis of small populational differences within a species, but are obviously ill-suited for use as generic characters except in a general way. The more conservative characters, those which tend to be identical from one individual to another within a species and which vary only within narrow limits within related groups, would seem to be preferable for use as indicators of interspecific relations. Such characters are found in certain details of scutellation, of the hemipenis, and of the skeleton. There is also an indication that some aspects of ontogenetic development may be useful as indicators. Unfortunately, little attention has been paid to these characters in the recent past. Thus comparison is limited to those few species which have had these features noted.

**SCUTELLATION**—The more conservative elements of scutellation observed in this study are the labials in contact with the eye, the size and relationship of the genials, the size and position of apical pits, and certain features of dorsal scale row reduction.

As indicated above, the eye in *Gonyosoma* is in contact with labials V and VI when there are 7 or 8 supralabials, and usually in contact with labials VI and VII when there are 9 or 10. This is in contrast to *Elaphe* where labials IV and V commonly contact the eye when there are 7 or 8 supralabials

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(the latter being the usual number in this genus) and V and VI are in contact when there are 9 or more.

The situation in *Lampropeltis*, another colubrine (*sensu* Dunn, 1928) genus in which the modes of change in various items of scutellation have been closely observed (Blanchard, 1921: 13), may be compared with this. This genus usually has labials III and IV in contact with the eye when there are 6 or 7 (the latter being the usual number), and IV and V when there are 8. The few *Lampropeltis* which have 8 supralabials, therefore, are similar to *Elaphe* in this respect, while *Gonyosoma* differs consistently at this number and overlaps in only occasional individuals (one specimen in 15) at higher counts.

The placement of these labials bears a direct relation to the length of the muzzle of these genera; it is shortest in *Lampropeltis*, moderate in *Elaphe*, and elongate in *Gonyosoma*.

The muzzle lengths and arrangements of labials seem to be among the best and most consistent differences in proportion

$$25 \frac{-6(18)}{-6(17)} 23 \frac{+6(42)}{+6(42)} 25 \frac{+7(74)}{+7(74)} 27 \frac{-7(116)}{-7(119)} 25 \frac{5 + 6(129)}{5 + 6(130)} 23 \frac{-5(134)}{-6(136)} 21 \frac{4 + 5(161)}{4 + 5(160)} 19(218)$$

Although simpler, the formula for *E. longissima* (USNM 19242) follows the same pattern.

$$21 \frac{+6(44)}{+6(44)} 23 \frac{-6(123)}{-6(125)} 21 \frac{4 + 5(136)}{4 + 5(135)} 19 \frac{4 + 5(164)}{5 + 6(174)} 17(224)$$

tion and scutellation between these three genera. It may be pointed out that, whereas

$$31 \frac{7 + 8(12)}{-7(12)} 29 \frac{+7(52)}{+7(52)} 31 \frac{+8(92)}{+8(93)} 33 \frac{-7(142)}{7 + 8(143)} 31 \frac{-7(153)}{-7(152)}$$

the total labial number would show no difference between *Gonyosoma* and *Elaphe*, and only a slight one between them and *Lampropeltis*, the placement of the labials in relation to the eye is more definitive. *Gonyosoma* differs from *Elaphe* in this character to about the same degree as the latter does from *Lampropeltis*, or perhaps somewhat more.

The reduced size of the postgenial plates in *Gonyosoma* to about half the size of the pregenitals (maximum observed is less than 60 percent), is not presaged in any of the species of *Elaphe* examined. In *Elaphe* the two pairs are about the same size or the posterior ones are only slightly smaller (minimum observed is more than 75 percent). In *Gonyosoma* the postgenitals are not separated from one another by other scales, but in *Elaphe* they are separated by one or more

(usually two) rows of small scales for their entire length.

The size and position of the apical pits on the dorsal scales appear to vary, individually or interspecifically, within narrow limits. Oliver (1948: 178) has previously pointed out that the distribution and number of these pits over the body may be phylogenetically important; the present study indicates that their size and position may be similarly so. In *Gonyosoma* the apical pits are elongate and close to the tip of the scale, while they are rounded and somewhat more distant from the tip in all species of *Elaphe* examined.

The scale reduction formula of *Gonyosoma* contrasts strongly with that of *E. quatuorlineata* (see descriptions above). Comparison of these formulae with those of other presumably related species allows further evaluation of this character. The formula for *Elaphe guttata* (UMMZ 84452) is:

$$29 \frac{5 + 6(160)}{5 + 6(159)} 27 \frac{-6(172)}{-6(173)} 25 \frac{4 + 5(204)}{-4(200)} 23 \frac{4 + 5(244)}{-5(244)} 21(256)$$

A species in which the reductions involve many more rows is *E. triaspis* (UMMZ 68235).

Formulae for other species of *Elaphe* (*E. carinata* Gunther, *E. dione* Pallas, *E. obsoleta* Say, *E. vulpina* Baird and Girard) are given by Clark and Inger (1942: 168-69), and by me for *E. flavirufa* Cope (Dowling, 1952: 4, 7, 8, 12), and *E. rosalia* Mocquard and *E. subocularis* (Dowling, 1957: 8, 13). A notable feature of these formulae is that in the genus *Elaphe*, whether a maximum of 23 scale rows or 39 scale rows is involved, the reductions are always approximately midlateral and the rows involved in the reduction of one species may be predicted from those of another.

Blanchard (1921: 9) pointed out long ago that a general reduction formula could be determined for the entire genus *Lampropeltis*. He compared this with one tentatively constructed for *Elaphe* from examination of a few specimens and pointed out the close similarity. Stull (1940: 16) did the same for

the genus *Pituophis*. Generalized formulae for the genera *Elaphe*, *Gonyosoma*, *Lampropeltis*, and *Pituophis*, using only those scale rows held in common, are interesting in this regard.

*Elaphe*:

$$27 \xleftarrow[\pm 6]{\pm 7} 25 \xleftarrow[\pm 6]{\pm 5} 23 \xleftarrow[\pm 5]{\pm 6} 21 \xleftarrow[\pm 4]{\pm 5} 19 \xleftarrow[\pm 4]{\pm 5} 17.$$

*Gonyosoma*:

$$27 \xleftarrow[\pm 13]{\pm 13} 25 \xleftarrow[\pm 12]{\pm 12} 23 \xleftarrow[\pm 3]{\pm 3} 21 \xleftarrow[\pm 10]{\pm 10} 19 \xleftarrow[\pm 9]{\pm 9} 17$$

*Lampropeltis*:

$$27 \xleftarrow[\pm 7]{\pm 7} 25 \xleftarrow[\pm 6]{\pm 6} 23 \xleftarrow[\pm 6]{\pm 6} 21 \xleftarrow[\pm 5]{\pm 5} 19 \xleftarrow[\pm 5]{\pm 5} 17$$

*Pituophis*:

$$27 \xleftarrow[\pm 6]{\pm 6} 25 \xleftarrow[\pm 6]{\pm 6} 23 \xleftarrow[\pm 5]{\pm 5} 21 \xleftarrow[\pm 5]{\pm 5} 19$$

Any frequent deviation (found in more than 10 percent of the observations) is shown on the lower row for *Elaphe* (no frequent deviations were found in *Gonyosoma*). It is clear from the above formulae that in this character *Elaphe*, *Pituophis*, and *Lampropeltis* show a close similarity, while *Gonyosoma* is completely dissimilar.

**HEMIPENIS**—The hemipenes of *Gonyosoma oxycephalum* and *Elaphe quatuorlineata* might both be described as, "Spinose proximally, calyculate distally; sulcus spermaticus single." However, this organ appears to be quite conservative in its main features, and such a description would also include *Coluber*, *Lampropeltis*, *Pituophis*, and many others. Thus any generic differences are necessarily concerned with smaller details of shape and ornamentation.

Although the hemipenes of *Gonyosoma oxycephalum* and *Elaphe quatuorlineata* differ in many ways, (Pl. I) it is more significant that the former differs in two distinct features from those of the ten species of *Elaphe* which have been examined. The hemipenis of *Gonyosoma* is covered with spinules which are found along the length of the organ except the extreme distal end, but in *Elaphe* any spinules present are restricted to a small area proximal to the main spinose area (vide Dowling, 1957: Pl. I). This is also true of *Lampropeltis* (Blanchard, 1921: 7, fig. 2) and *Pituophis* (Stull, 1940: 10, fig. 6). In *Gonyo-*

*soma* the main spines are restricted to a patch opposite the sulcus, while in *Elaphe* they occur in a band which completely encircles the hemipenis proximal to a well-differentiated calyculate area (vide also Cope, 1900: pl. 14, Fig. 2).

**SKELETAL CHARACTERS**—The skull of *Gonyo-*

*soma* differs from that of the species of *Elaphe* which were examined (see list of specimens) in almost every element. Such skull differences are difficult of description, however, and only four elements, prefrontal, squamosal, quadrate, and palatine, are closely compared here (Fig. 2).

Although differing considerably in shape, the prefrontal of *E. triaspis* approaches that of *Gonyosoma* most closely in proportions, having a length/height ratio of about .90. This may be compared with the maximum otherwise observed (in *E. obsoleta*) of .73. However, there is actually no close approach to the proportions of the longer than high (length/height ratio 1.17) element of *Gonyosoma*, nor do any species of *Elaphe* have a prefrontal with a dorsomedial extension as in *Gonyosoma*.

The squamosal is small in *Gonyosoma* and its length-relation with the quadrate is not approached in any species of *Elaphe*. In all species of the latter the squamosal is equal to (as in some *E. obsoleta*) or larger than the quadrate, while in *Gonyosoma* the former has a length equal to only 81 percent of the latter. Nor does the squamosal in any species of *Elaphe* have the strongly tuberculate articulating surface found in *Gonyosoma*, the nearest approach being a weakly indicated ridge in this area in *E. obsoleta* and *E. triaspis*. This tubercle on the squamosal's articulating surface allows the quadrate of *Gonyosoma* to

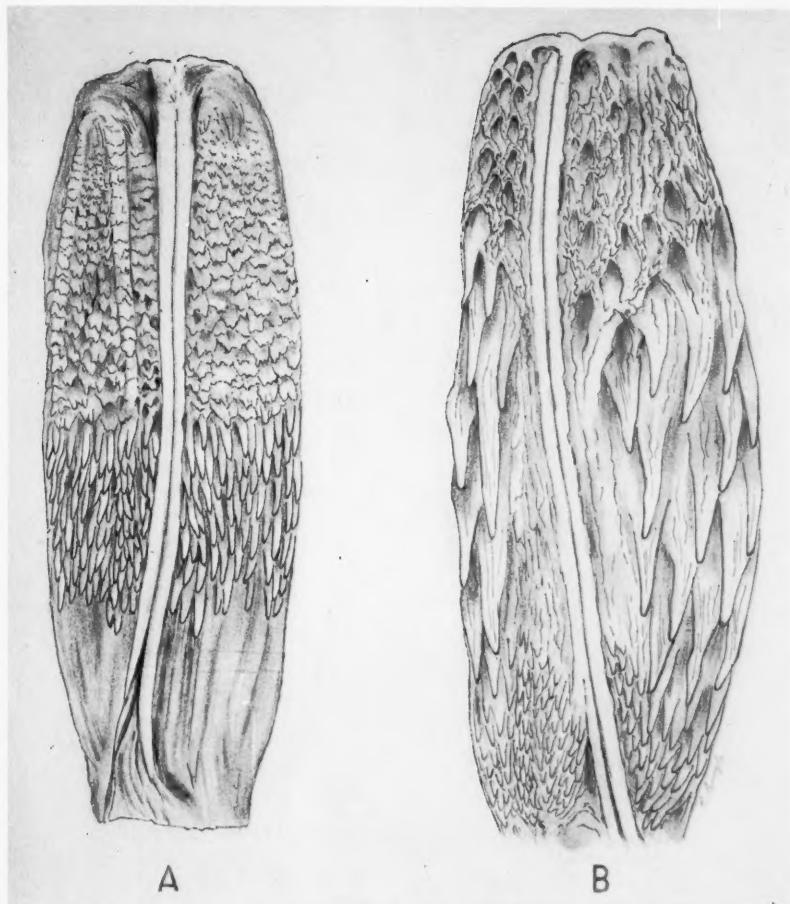


Plate I. Hemipenes of (a) *Elaphe quatuorlineata* Lacépède, and (b) *Gonyosoma oxycephalum* Boie. The complete band of spines proximal to the calyculate area is characteristic of the genus *Elaphe* as here understood. The spine-free area near the sulcus in *Gonyosoma*, which due to folding appears less extensive here than it actually is, is not found in any species of *Elaphe* examined; neither is the spinulose calyculate area. [Drawn from retracted hemipenes which were split longitudinally and spread flat. *E. quatuorlineata* drawn from USNM 37322 and checked against USNM 56331; *G. oxycephalum* drawn from USNM 29572 and checked against four other specimens.]

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be square-ended proximally, while the quadrates of species of *Elaphe* all have slanted articulations here. The shaft of the quadrate is round near its midpoint in *Gonyosoma* but flattened and bladelike in *Elaphe*. The ossified point on the quadrate where the columella contacts it is proximal to the narrow "neck" in *Elaphe*; distal to it in *Gonyosoma*.

The palatine of *Gonyosoma* is one of its most distinctive elements, and its differences (Fig. 2) must indicate some considerable difference in usage between the genera. The relative size and shape of the median process

ontogenetic development would seem to be particularly valuable as indicators of relationship, or lack of it. Two such ontogenetic features were noted in this study, one involving the color pattern, the other concerned with the keeling of the dorsal scales.

One significant feature of the color pattern of *Elaphe* is that whether the adult snakes are blotched, striped, or unicolored, the young always have a pattern of dark blotches on a light background. This is true not only of the American and European species considered here, but also of many Asiatic species not in-

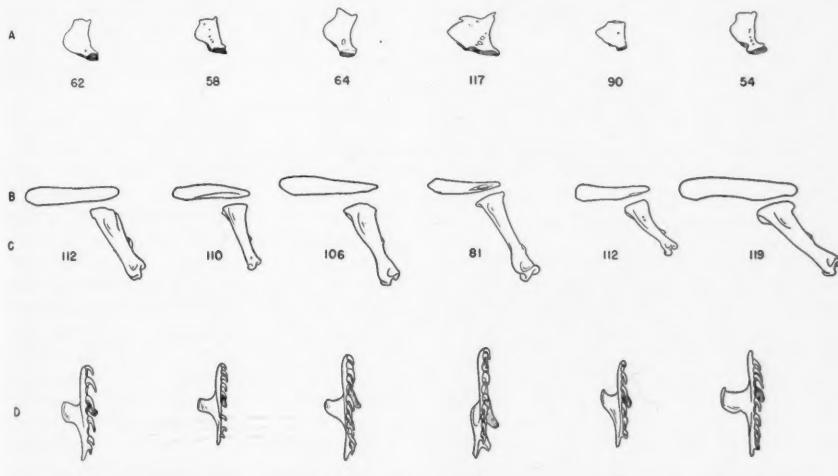


Fig. 2. Comparison of certain bones of the skull in *Gonyosoma* and *Elaphe*. The long low prefrontal, the small squamosal, and the short median process of the palatine are all diagnostic characters for *Gonyosoma*. Horizontal rows are (a) prefrontal, (b) squamosal, (c) quadrate, and (d) palatine bones. Vertical columns are (1) *E. guttata*, (2) *E. quatuorlineata*, (3) *E. obsoleta*, (4) *G. oxycephalum*, (5) *E. triaspis*, and (6) *E. vulpina*. Proportional measurements are length/height in (a), and squamosal/quadrata length in (b, c).

is perhaps its outstanding feature, but the lateral process as well differs in both size and position.

The midthoracic vertebrae appear to be more variable, interspecifically, than the above skeletal elements, but two features are consistently different between *Gonyosoma* and the twelve species of *Elaphe* which were examined. The articular surface of the prezygapophysis is subrectangular in *Gonyosoma*, oval to ovate in *Elaphe*. The haemal keel projects over the neck of the condylus almost to the articulating surface in *Gonyosoma*, but ends anterior to the neck in *Elaphe* (Fig. 3).

ONTOGENETIC FEATURES—Although not readily usable as key characters, features of

cluded in this study (*vide* Stejneger, 1907: 314, 326). The young of *Gonyosoma*, in contrast, are described as essentially unicolor with "narrow oblique light bars" (De Rooij, 1917: 105) posteriorly. This type of coloration, juvenile or otherwise, is not found in any known species of *Elaphe*.

The keeling of the dorsal scales in *Gonyosoma* appears to vary from weakly keeled to smooth, while that of *Elaphe* (in different species) varies from moderately (*E. quatuorlineata*) through weakly keeled (*E. guttata*) to smooth (*E. rosaliae*) at midbody. However, the keeling (as indicated in the description) in *Gonyosoma* appears to bear no relation to the size of the snake, nor to the part of the

body considered. Conversely, in *Elaphe* the small individuals of a species have much less dorsal keeling than do the large ones, and the keeling is always heaviest near the posterior end of the body. This was pointed out previously in *E. guttata* and *E. oboleta* (Dowling, 1951a: 41) and has proven to be true in all species of this genus which have been examined for this character.

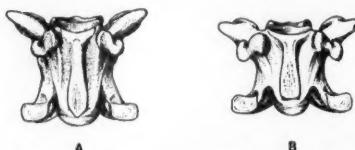


Fig. 3. Ventral views of midthoracic vertebrae in (a) *Gonyosoma oxycephalum* and (b) *Elaphe quatuorlineata*. Consistent differences, as indicated by examination of other species of *Elaphe*, are the shape of the pre- and postzygapophyseal articular surfaces and the length of the haemal keel.

#### GENERIC SUMMARIES

The numerous comparisons made above demonstrate that *Gonyosoma oxycephalum* Boie, the type species of its genus, differs markedly from *Elaphe quatuorlineata* Lacépède, the type species of its genus. Comparison of the characteristics of these two species with those of other European and American species currently recognized in *Elaphe* further demonstrates that *G. oxycephalum* differs from all of them in most of the same qualitative features. Since the features in which *G. oxycephalum* differs are those which appear to demonstrate best the relationships indicated in other species allocated to *Elaphe* it seems clear that *Gonyosoma* and *Elaphe* have attained at least a generic level of differentiation. Their recognition as distinct and separate genera is not only justified, but desirable. Their diagnoses follow.

#### *Gonyosoma* Wagler

*Gonyosoma* Wagler, 1828: text to pl. 9 (type species, by monotypy, *G. viride* Wagler [= *Coluber oxycephalus* Boie, 1827]).

**DIAGNOSIS**—A genus of colubrine snakes (*sensu* Dunn, 1928: 18) differing from *Elaphe* Fitzinger in having dorsal scales with elongate apical pits, several paravertebral reductions in the dorsal scale rows, and a loreal at least twice as long as high; hemipenis with a patch of elongate spines opposite sulcus and proximal to a short spinulose calyculate

area; squamosal shorter than quadrate and having an external tubercle; palatine with median process shorter than lateral one; haemal keel of midthoracic vertebrae extending posteriorly over neck of condylus.

**CONTENT**—*G. oxycephalum* Boie (including *G. janseni* Bleeker, *C. enganensis* Vinciguerra) is the only species now recognized in this genus. Although *Gonyosoma* as here recognized, is monotypic, examination of the diagnostic characters in other Eurasian (and particularly Oriental) snakes will probably permit the allocation of other species here. However no other species are referable to *Gonyosoma* on the basis of published literature; the enlarged "vertebrals" (actually paravertebrals) noted by Smith (1943: 145) in *G. oxycephalum* were not noted in other species studied by him.

Allocation of *Elaphe frenata* Gray and *E. prasina* Blyth to *Gonyosoma* was made by Günther (1864: 293), and was again advocated by Pope (1935: 227), but it does not appear to be warranted. Although these two species appear closely related to one another, neither appears to approach *G. oxycephalum* except in the green coloration. They do not possess the long snout or elongate loreal plate of *Gonyosoma* (*vide* Bourret, 1936: figs. 82, 83); labials entering the eye are III, IV, V when there are 8 and IV, V, VI when there are 9 (*Ibid.* fig. 83; Pope, 1935: fig. 53), rather than the V, VI and VII condition characteristic of *Gonyosoma*; and the postgenials are not reduced and are separated by smaller scales (Pope, 1935: fig. 53). Descriptions of the hemipenes (Pope, 1935: 245, 260; Smith, 1943: 143) show them to differ considerably from that of *Gonyosoma*.

**RANGE**—The southern Oriental region: southeastern Burma eastward through Indo-China to the Philippines, and southward through Malaya and the East Indies to Lombok and Celebes.

#### *Elaphe* Fitzinger

*Elaphe* Fitzinger in Wagler, 1833: text to pl. 27 (Type species, by monotypy, *E. parreyssi* Wagler [= *Coluber quatuorlineata* Lacépède, 1789]).

**DIAGNOSIS**—A genus of colubrine snakes differing from *Gonyosoma* Wagler in having dorsal scales with rounded apical pits, mid-lateral reduction of the dorsal scale rows, and a loreal (when present) little longer than high; hemipenis with a complete band of

spines proximal to calyculate area, than quadrangular, and much larger than condylus.

**CONTENT**—*Elaphe* living, 1951, are currently discussed.

**RANGE**—slightly in the eastern Peninsula of South America, and out the continent to Australia, Australia.

While the range of *Gonyosoma* might seem to be limited by its distribution, this is not the case. The genus cannot be limited to the narrow, wide basis of the type locality and include all species which are similar to *Elaphe* in having a long snout and a narrow calyculate area. European and American species which are similar to *Elaphe* in having a long snout and a narrow calyculate area, and which are not similar to *Gonyosoma* in having a long snout and a narrow calyculate area, should be properly placed in *Gonyosoma*. Consideration of the characters of the type locality of *Gonyosoma* is therefore not necessary for the current discussion on the genus. Several Old World species of *Coluber* generally placed in *Elaphe* have been evaluated by Pope (1935) and it is shown that they differ considerably from the type locality of *Gonyosoma*.

**Although** the characters of "genera" of *Elaphe* are not specific characters of the genus, the workers have grouped the species in *Elaphe* into groups which are in general agreement with the totality of the characters of the type locality of any one species. At this point, however, the characters of *Coluber* and *Elaphe* are not the same, and the characters of *Elaphe* may be used to distinguish the two genera. *Gonyosoma* must be distinguished from *Elaphe* by characters defining the genus.

spines proximal to an extensive nonspinulose calcareous area; squamosal as long as or longer than quadrate, smooth or with a weak articular ridge; palatine with median process much larger than lateral process; haemal keel of midthoracic vertebrae ending anterior to condylus.

CONTENT—Seven American species (Dowling, 1952b) and about 30 Eurasian species are currently allocated to this genus (see discussion below).

RANGE—The Holarctic realm, extending slightly into the Neotropical region (the Yucatan Peninsula and the highlands of Costa Rica), and, as currently understood, throughout the Oriental region. Not found in Australia, Africa, or South America.

#### DISCUSSION AND SUMMARY

While the above diagnosis of *Gonyosoma* might serve almost equally well as a definition, this is not true for *Elaphe* which still cannot be adequately defined on a worldwide basis. A definition broad enough to include all Eurasian species currently allocated to *Elaphe* would also include species now placed in *Arizona*, *Pituophis*, and *Spilotes*. A narrow definition including only the European and North American species would exclude many Asiatic forms which could not be properly allocated to other genera without considerable further study. It seems better, therefore, to leave *Elaphe* undefined, as it currently stands, until the essential information on the other species can be obtained. Several Old World species now placed in the genera *Coluber* and *Zamenis* should be re-evaluated in such a study. It may be pointed out that these two genera, along with several others (i.e. *Natrix*), share the undefined status of *Elaphe*. Monographic studies of them on a worldwide basis are much to be desired.

Although Cope (1900: 705) tended to think of "generic characters" as distinct from "specific characters" or "familial characters," later workers have recognized that supraspecific groups must be defined on the basis of the totality of characters rather than on the basis of any one. Bogert (1947: 10) has emphasized this point of view in relation to the genus *Coluber* and others. Thus while the type of scale reduction or hemipenial ornamentation may be used as key characters to differentiate *Gonyosoma* from *Elaphe*, these characters must be considered in relation to others in defining these groups. Examination of these genera from this viewpoint seems to indicate

that *Gonyosoma* bears little or no close relationship with *Elaphe* and has been placed with it in the past due only to a general similarity of tooth length and numbers of scales. These general resemblances appear to be offset by many qualitative differences in the scutellation, hemipenis, and skeleton, and are probably to be thought of as adaptive or incidental, rather than indicators of relationship.

#### ACKNOWLEDGMENTS

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I am particularly grateful to Dr. Doris M. Cochran, U. S. National Museum (USNM) for her rapid reply to my plea for specimens, to Mr. T. P. Haines, Mercer University, for the loan of skulls from his private collection (TPH), and to Dr. Walter Auffenberg, University of Florida, for the loan of midthoracic vertebrae from his private collection (WA). Thanks are also due Dr. James A. Peters, Brown University, who sent a copy of his comments on Mertens' proposal to suppress the name *Gonyosoma*. Fellow herpetologists here, Drs. Walter Auffenberg, Coleman J. Goin, Arnold B. Grobman, and William J. Riemer, have provided me with much welcome stimulation through their discussion and constructive criticism. Many valuable suggestions from my editor and coworker, Margaret P. Dowling, have been incorporated into this paper.

#### LIST OF SPECIMENS

Entire specimens of the following species were studied.

*Gonyosoma oxycephalum*. Borneo (USNM 38539); Jahore (USNM 29572); Java (USNM 43282-85); Malacca Straits, Great Kariman Id. (USNM 33174); Philippine Is., Lubang Id. (USNM 39927); Sumatra (USNM 29423, 70971); Sumatra region, Pulo Nias (USNM 31672), South Pagi Id. (USNM 31693); Tampelan Is., Pula Bunoa (USNM 26571). *Elaphe longissima*. Spain (USNM 19241-42). *Elaphe quatuorlineata*. Italy (USNM 56531); Ro-

mania (USNM 37322); Yugoslavia (USNM 37321). *Elaphe taeniura*. Borneo (USNM 130243).

Skulls of the following species were examined. *Gonyosoma oxycephalum* (USNM 33155).

*Elaphe guttata* (TPH 316, 323, 673); *E. longissima* (Academy of Natural Sciences of Philadelphia); *E. obsoleta* (TPH 214, 305, 311, 314, 358, 663, 664, 676, plus 2 unnumbered; WA 3 unnumbered); *E. quatuorlineata* (TPH 273); *E. triaspis* (University of Michigan Museum of Zoology unnumbered); *E. vulpina* (TPH 516, plus 1 unnumbered).

Midthoracic vertebrae (all from the private collection of Walter Auffenberg) were examined from the following species.

*Gonyosoma oxycephalum*.

*Elaphe climacophora*; *E. dione*; *E. guttata*; *E. longissima*; *E. obsoleta*; *E. quatuorlineata*; *E. scalaris*; *E. shrencki*; *E. situla*; *E. subocularis*; *E. triaspis*; *E. vulpina*.

Other data were taken from my personal notes on the American members of the genus *Elaphe*.

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1833. *Ibid.* Pt. III. 2 pp. (unnumbered) + pls. 1-36 with accompanying text.

This report is based on the collections of the *osceola* and *subspinosus* subspecies of *serpentinus*, the current status of which is not mentioned. The young of *osceola* are up the current turtle by subspecies.

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# The Status of the Florida Snapping Turtle

## *Chelydra osceola* Stejneger

NEIL D. RICHMOND

STEJNEGER (1918) described from Pinellas County, Florida, a new species of snapping turtle, *Chelydra osceola*, distinguished from northern *Chelydra serpentina* as follows: "Diagnosis—Similar to *Chelydra serpentina*, but central laminae of carapace relatively much wider, width of third central being one-third the length of the five centrals together, or more; knobs of dorsal keels located nearer center of laminae; four small chin barbels." Babcock (1932) concluded that *osceola* did not warrant full specific rank, because the characters used by Stejneger to distinguish *osceola* came within the range of variability of *serpentina*. Rust (1934) listed *osceola* as a subspecies of *serpentina*, a usage followed in the current check lists (Schmidt, 1953; Mertens and Wermuth, 1955). Pope (1939) did not mention *osceola*, although he figured a young one (Pl. 21, opp. p. 82) as *Chelydra serpentina serpentina*. Carr (1952) summed up the current status of the Florida snapping turtle by terming it a "weakly differentiated subspecies."

This review of the status of *C. osceola* is based on a study of 17 preserved specimens of *osceola*, four complete skeletons, 11 skulls, four carapaces only, and the preserved head, feet, and tail of a large specimen. These were compared with the Carnegie Museum collection of 169 specimens of *serpentina*, including 16 skulls and six complete skeletons.

The specimens of *osceola*, including skeletal material, came from the following Florida counties: Alachua 11, Broward 2, Collier 1, Dade 5, Lake 1, Palm Beach 1, Polk 2, Putnam 1, Volusia 1. In addition, there were two specimens labelled "Baker Co., Ga." but there is some question as to whether these came from Georgia or from Baker County, Florida.

The 55 specimens of *serpentina* used for external measurements included 32 from South Carolina and 23 from various other eastern states. The most southerly localities from which *serpentina* were examined are Beaufort and Charleston Counties in south-east South Carolina.

The measurements discussed here were taken as follows: The carapace length is the straight line distance from the middle of the precentral to the seam between the postcen-

trals. The carapace width is the maximum width of the carapace measured in a straight line. The width of the 3rd central is the length of the anterior seam of the 3rd central. This is not the maximum width as this central may be strongly hexagonal. The height of the 2nd lateral was measured from the point of the seam that touches the 2nd and 3rd central to the seam between the 6th and 7th marginal and is usually the maximum dimension of this lamina. The head width is the width of the head measured at the level of the tympana.

No plastral measurements were used as even in this small sample there was great variation in the relative proportions of the anterior and posterior parts of the plastron as well as conspicuous variation in length and width of the bridge.

For the loan of specimens I am indebted to Dr. William J. Reimer, Florida State Museum, and to Dr. Albert Schwartz, Charleston Museum. I also wish to express my appreciation to Dr. Coleman Goin and to Dr. Archie Carr of the University of Florida for their helpful suggestions as well as for examining additional specimens. Dr. Walter Auffenberg of the University of Florida deserves especial thanks for obtaining most of the skeletal material used in this study.

### DISCUSSION

As Babcock (1932) mentioned, the shell characters of *osceola* as given by Stejneger are constant for the Florida form. The number of chin barbels is the only character mentioned in the diagnosis that is too inconstant to be of value. The position of the knobs of the fourth and fifth central laminae are more nearly central in *osceola* than in *serpentina*. This is especially apparent on the fourth central where the knob is always on the posterior margin in *serpentina* but is well separated from the margin in *osceola*. The knobs of the fourth laterals are located on or near the corner of the lamina in *serpentina* but are well separated from the margin in *osceola*. These apparently minor differences in the posterior laminae reflect a major difference in the shape of the carapace of the

two turtles. In *osceola* the shell is relatively high in the region of the pelvic girdle and slopes abruptly to the posterior marginals. In *serpentina* the entire carapace is flatter and slopes gradually to the posterior marginals.

The following external characters show differences sufficiently constant to be useful for separating the two forms. The dorsal surface of the neck of *osceola* has numerous long, pointed, fleshy tubercles that give the turtle a characteristic shaggy appearance, like that of *Macroclymys*. The same area in *serpentina* has numerous rounded wart-like scales. In *serpentina*, the temporal and occipital regions of the head are covered with flat, juxtaposed plates that become smaller posteriorly (illustrated in Carr, 1952, p. 60). In *osceola*, this same area is covered with fine

such a way that it could be readily applied and would be constant for various sizes of turtles.

There are a number of other characters that distinguish the two forms but they are more variable, subject to changes with age, or are more subjective. The beak of the upper jaw is characteristically narrow and sharp pointed in all sizes of *osceola*; in *serpentina* it is pointed in young specimens, but in very large ones it is usually rounded and thickened. The dorsal surface of the hind limb and of the upper arm in *serpentina* is studded with numerous round, wart-like scales. In *osceola*, the scales are uniform and minute, giving the appearance of being smooth.

In addition to these external characters there are striking skeletal differences which appear significant although the number of skeletons available does not permit final conclusions.

Eleven skulls of *osceola* were compared with 16 skulls of *serpentina*. Of the differences noted the following were the most constant:

The skull of *osceola* is broader and flatter than that of *serpentina*. The palate is broad and flat in *osceola*, narrower and arched in *serpentina*. The bony roof of the supratemporal fossa is more extensive in *serpentina*. The width of the narrowest portion of the arch formed by the combined postfrontal and jugal bones is as great or greater than the width of the palate in *serpentina*, but usually much less in *osceola*.

Eight carapaces of *osceola* were compared with six of *serpentina*. The most apparent and distinctive difference between the two forms is the relative length and size of the free part of the ribs. The ribs of *osceola* are extremely long and slender between the vertebrae and where they join the carapace. The area enclosed by the ribs is much wider than the skull in *osceola*; in *serpentina* it is approximately the same width. The maximum width of this area, measured at the ends of the third pair of ribs is approximately one-third the length of the carapace in *osceola*, but only one-fourth in *serpentina* (See Table I). In specimens of comparable size this area is 15-30 percent wider in *osceola*. The ribs of *osceola* extend with only a slight curve from the vertebrae to where they join the carapace while in *serpentina*, the ribs are strongly curved upwards to meet the carapace.

In the four complete skeletons available, the scapula of *osceola* is relatively longer than that of *serpentina*; the scapula is longer

TABLE I

Ratio		N	Mean	Min.	Max.
Rib Span	<i>osceola</i>	8	31.9	29.6	35.8
	<i>serpentina</i>	5	25.4	24.4	26.6
Width of Central 3	<i>osceola</i>	21	91.2	80.0	106.0
	<i>serpentina</i>	40	74.3	66.7	84.3
Height of Lateral 2	<i>osceola</i>	21	31.3	29.2	35.0
	<i>serpentina</i>	40	26.4	24.0	31.3
Width of Central 3	<i>osceola</i>	21	31.3	29.2	35.0
	<i>serpentina</i>	40	26.4	24.0	31.3
Carapace Length	<i>osceola</i>	21	31.3	29.2	35.0
	<i>serpentina</i>	40	26.4	24.0	31.3

granular scales, not plates, and these are pointed tubercles bordering the parietal.

In *osceola*, the width of the third central (measured along the anterior edge) is approximately equal to the height of the second lateral while in *serpentina* the relatively narrow third central averages 74 percent of, and is always less than, the height of the second lateral (See Table I). Stejneger (1918) compared the width of the third central with the length of the five centrals; however, Babcock found that this ratio would not separate the two forms. The greater width of the third central is also apparent when expressed as a ratio of carapace length. This ratio averages 26.4 (24.0-31.3) in 40 *serpentina* and 31.7 (29.4-35.0) in 15 *osceola*. The two specimens of *serpentina* with the highest ratios are from montane areas, one in North Carolina and the other in West Virginia, and are thus far removed from any area of possible intergradation. As Stejneger observed, the great width of the central laminae is one of the most distinctive features of *osceola*. The only difficulty has been in expressing this difference in

than the *tina*. The *associated* *osceola*.

The *a* straight *ceola*. The *in* *serpe* angle; *in* *edge co* angle.

The *in* *cave to* *in* *tina*; it

The *in* *serpe* *lateral P* or *great* *osceola*, the *length*

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a. *Temp* *juxta* *with* *3rd co* *lateral*  
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CRIPT  
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lizard (*Ph*)

than the skull in *osceola*, shorter in *serpentina*. The longer scapula is presumably associated with the relatively higher carapace of *osceola*.

The anterior edge of the ilium is almost straight in *serpentina* but curves back in *osceola*. The top of the ilium is straight edged in *serpentina* with an anterior and posterior angle; in *osceola* the curve of the anterior edge continues over the top to the posterior angle.

The mesial face of the ilium is deeply concave to fit the end of the sacral rib in *serpentina*; it is almost flat in *osceola*.

The ventral part of the pelvic girdle is wide in *serpentina*, the width across the ventrolateral processes of the pubis being the same or greater than the length of the ilium. In *osceola*, this width is approximately two-thirds the length of the ilium.

A detailed comparison of skeletal material of the two forms disclosed a number of minor differences in the cervical vertebrae, hyoid, pelvic girdle and the large limb bones that might be of value in identifying fossils of these two forms. However, enough specimens have not been studied to determine how these characters vary with sex and age.

In view of the many differences between snapping turtles from peninsular Florida and those from northern states, involving structural modifications of the skull, carapace, and limb girdles, it would appear that the two forms are specifically distinct unless it can be demonstrated that they do interbreed and intergrade. Carr's statement (1952) that they intergrade in Alachua and adjacent counties is not supported by any evidence. In fact, the eleven specimens examined from Alachua County are all *osceola*.

The two species of *Chelydra* in the United States may be identified by the following key:

a. Temporal region and back of head with flat juxtaposed plates, dorsal surface of neck with rounded wart-like tubercles, width of 3rd central much less than height of second lateral ..... *serpentina*.  
 aa. Temporal region and back of head with granular scales and scattered tubercles, dorsal

surface of neck with long pointed tubercles, width of 3rd central the same as or greater than height of second lateral ..... *osceola*.

The fact that *osceola* is restricted to peninsular Florida and is so completely distinct from *serpentina* implies a long residence in its present range. It has probably been in Florida since early Pleistocene. The types of *C. laticarinata* Hay and *C. sculpta* Hay from Pleistocene deposits in Florida consist of peripheral bones only and it may be presumed that Hay compared them with northern specimens of *serpentina*. In view of this, it would seem not unlikely that one of these extinct forms will prove to be conspecific with *osceola* when suitable comparative material is studied. In the absence of such material, it is still possible to observe that the principal diagnostic character of *C. laticarinata*, (the pronounced keel on the sixth peripheral) is also characteristic of *osceola*.

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## Herpetological Notes

CRYPTIC COLORATION IN LAVA-DWELLING HORNED LIZARDS.—The desert horned lizard (*Phrynosoma platyrhinos calidarium*) typi-

cally inhabits areas of sandy or gravelly soil, and at times is found among scattered rocks. It is frequently encountered completely or partly buried

in the sand. Markings on this species are usually bright; the dorsal ground color is usually light-orange with irregular brown bands bordered posteriorly by grayish-yellow bands, and the ventral ground color is white with few dark spots. The colors exhibit considerable individual variation in any population and also undergo a range of changes induced by temperature and substrate.

On June 5, 1957, two very darkly pigmented individuals (MVZ 65927 and 65928) were found on the mosaic of black lava and buff sand surrounding Amboy Crater, the easternmost volcanic cone in a chain extending from Ludlow to Amboy, San Bernardino County, California. The adult (65928) has a brick-red dorsal ground color with wide irregular black crossbands and small yellow spots scattered along the middorsal line. Banding is not as evident on the young individual (65927), in which the ground color is dark-gray. The ventral color of both individuals is white with abundant dark spots. The gular region is gray in the adult and white in the young specimen. A third dark specimen (64017), collected by Robert C. Stebbins on the Amboy Crater area in 1955 was also examined. This animal, although in preservative for two years, displays an extremely dark dorsal pigmentation.

Atsatt (1939, *Publ. Univ. Calif. Los Angeles Biol. Sci.*, 1: 260-61) described experimentally induced color changes in this species in relation to temperature and light, but also stated that individuals tended to match the background color of their substrate and that they retained the original range of color characteristics although kept for a year in a terrarium. Although the physiological changes were discussed in detail, no mention of a selective advantage of the stable color features was made. We believe that the dark color of the Amboy specimens may have a genetic basis, for during the period of one month, the two dark animals and one pale one from a different area have been kept captive under identical conditions of light and temperature and have retained their distinctive colors. The same individuals kept an additional month at high temperature (90-95°F.) also maintained their respective color appearances. Furthermore two individuals collected, at the same time, from Four Corners, San Bernardino County, where they lived under climatic conditions much like those of Amboy, but where dark rocks were not present, were pale.

It seems likely that the color of the Amboy specimens reflects selection for cryptic coloration. Since the sand in the area is pale in color, it might seem unlikely that the black coloration would be advantageous as a means of concealment. However, when these horned lizards are

partly buried in the sand, or even when completely exposed, they resemble the abundant small black rocks that are scattered throughout the sandy areas on the lava flow.—JOHN LAWRENCE AND DANIEL WILHOFT, *Museum of Vertebrate Zoology, Berkeley, California*.

THE VARIED CALLS OF THE BARKING TREEFROG, *HYLA GRATIOSA* LECONTE.—The barking treefrog, *Hyla gratiosa* LeConte, is widespread in the Southeastern United States, but is not often encountered except after hard rains. Then its breeding call may be heard coming by night from deep rainwater pools. This call, a single resonant note repeated at intervals of about two seconds, has been likened to a large gong or church bell (Deckert, 1915, *COPEIA*, No. 18: 5), or to the noise made by pounding on a hollow, heavy barrel (Wright, 1932, *Life-histories of the Frogs of Okefenokee Swamp, Georgia*: 299). The note has been transliterated as "tonk" (*idem*) or "doonk" (Cahn, 1939, *COPEIA*, 1: 52). This breeding call has been recorded (Kellogg and Allen, no date, *Voices of the Night*, revised ed., Side 1: Part 2).

Wright and Wright (1949, *Handbook of Frogs and Toads*, 3rd ed.: 327) stated of *Hyla gratiosa*, "The call in the [breeding] ponds is *coot bet*." Previously, Wright (*loc. cit.*) had explained that residents of Okefenokee Swamp named this frog "coot bet" from the sound produced when two individuals were calling not quite synchronously. To my ear the asynchronous calling of two individuals does not suggest the phrase "coot bet." However, when only two of these frogs are calling, they do so on different notes. One individual will voice a note which I would transliterate as "toonk." It is answered by another individual singing a different note which I would render as "tonk." Therefore, when only two of these frogs are calling, one hears "toonk-tonk... toonk-tonk... toonk-tonk." The third individual to join the chorus does so with yet another note, which may be rendered "tunk." There is a greater difference between the calls of the first and second frogs than between those of the second and third. When a sizeable chorus is heard from a distance, the notes of "toonk" stand out, so to speak, against a background of the other two notes, so that one might easily conclude that only two notes are being sung. Three notes are most readily distinguished when a chorus is just starting, and the trios just beginning to form. The order of call is unvarying: "toonk-tonk-tunk."

Sometimes a male, attempting to initiate a chorus, will receive no response. After fruitlessly calling "toonk" a few times, it will then voice six or seven "toonks" in rapid succession, with

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no measurable interval between the notes. Usually this will stimulate others to reply.

The circumstance calls to mind the studies of Goin (1949, Quart. Jour. Fla. Acad. Sci., 11 (2-3): 59-61) on *Hyla crucifer bartramiana* Harper. Goin found that choruses of the southern spring peeper were initiated by a frog singing a note of A. This individual was always answered by one singing a note of G\*, and the latter was in turn answered by one singing a note of B. The "peep order" was unvarying: A-G\*-B; and a chorus of peepers was actually a number of trios. A male, attempting to initiate a chorus, would sing a note of A a few times, and if no response was forthcoming, would utter a trill which was usually effective in stimulating the others of the trio to call.

Verbal descriptions of frog calls are not wholly satisfactory, and it is to be hoped that the breeding notes of *Hyla gratiosa* can some day be analyzed more objectively, perhaps by sound spectrograms. In the meanwhile it can be stated that the phenomenon which Goin (*loc. cit.*) called "peep order" is not confined to *H. crucifer* but occurs in *H. gratiosa* as well.

There is yet another problem relating to the calls of *Hyla gratiosa*.

Most examples of this species have been collected from breeding aggregations, the frogs being found in the water or not far above it on low vegetation, brush piles and tree boles. The usual whereabouts of non-breeding individuals has been uncertain. LeConte (1856, Proc. Acad. Nat. Sci. Phila., 8: 146) found a specimen that had concealed itself in a hole in the sand. Carr (1940, Univ. Fla. Pubs., Biol. Sci. Ser., 3 (1): 60) dug four examples from sand at a depth of more than four feet, and suggested that this frog was subterranean except during the warmer months. I found many individuals in sand at the bases of wiregrass clusters, and saw others that had been plowed up by rural residents (Niell, 1952, COPEIA, 3: 196). More recently, in Marion County, Florida, I found additional specimens in sand beneath logs near the edge of a flatwoods pond.

Within the range of *Hyla gratiosa*, one sometimes hears a raucous, repetitive barking coming usually from the treetops. It is reminiscent of the "kow-kow-kow" call of the yellow-bellied cuckoo; and is also something like the gobble of a turkey cock, although slower and more prolonged. It can be imitated closely with a turkey-call of the sort used by hunters. This barking virtually defies transliteration; it might be rendered approximately as "uk-oh-oh-oh-oh-oh-oh-oh-oh-oh," there being nine or ten raucous syllables in immediate succession. The call is utterly unlike the breeding note of *H. gratiosa*,

yet it has been ascribed to that species. In fact the common name of "barking treefrog," now generally used for *H. griseosa*, referred originally to this little-known tree call and not to the more familiar breeding song.

I believe that few herpetologists have heard the barking call; and, so far as I can learn, Wright (*op. cit.*: 300) is the only one to report a definite field identification of the "barker." For two seasons he was puzzled by the call, but at last he was able to watch a frog as it voiced this cry; it was *Hyla gratiosa*. To judge from the literature, then, *H. gratiosa* is (1) a fossorial frog whose call is a single resonant note; and (2) an arboreal frog whose call is a raucous barking. This situation was thought to merit further study (Neill, *loc. cit.*).

For about three years I resided within 100 feet of a pond where *Hyla gratiosa* often bred. This pond was on a tract known as "The Hammock," the property of Ross Allen on the western outskirts of Silver Springs, Marion County, Florida. Although a natural feature, the pond had been slightly enlarged and deepened by man. It lay within a liveoak hammock; beyond the live-oaks was a turkey-oak and longleaf pine association. During the summer, the breeding note of *H. gratiosa* was often heard by night from the pond, and the barking call by day from the tops of the liveoaks and pines.

It was impossible to scale the trees from whence the barking calls originated, and even with binoculars I could not locate the callers. One of the supposed frogs barked sporadically each summer day in the top of a pine about 90 feet from my house. One evening this barker (designated No. 1) began to descend, calling at intervals. When about two-thirds of the way down the pine, it moved into a small oak which grew nearby. It then moved horizontally through this and other small oaks and pines, heading for the pond. Its route could be traced approximately by its occasional calls. Finally it moved onto an oak limb about nine feet above the water. I could vaguely see the caller but could not identify it in the gathering dusk. To my surprise it leaped into the water from this height. The moment it bobbed up, it began voicing the breeding note of *Hyla gratiosa*. I caught the frog to verify the identification. At a later date, many captive examples of this species gave the barking call, sometimes in answer to wild ones in the hammock.

With the barking call identified, I attempted to discover the circumstances under which it was given.

In Marion County, Florida, the barking is heard as early as March 1 and as late as October.

23. Carr (*loc. cit.*) termed this call a rain-song, but the name is inappropriate, for it is most often heard on bright, sunny days. If the morning is clear, it may be voiced as early as 6:15 AM. It is voiced sporadically through the day and at dusk, but never long after dark; and is always given from the trees. The breeding call, in contrast, is given from dusk to dawn, and occasionally on dark, rainy afternoons. Some nocturnal breeding choruses do not hush until well after the sun is up, but otherwise the breeding note is not uttered in bright sunlight. Unlike the barking call, the breeding note is given from the water, or (rarely) from brush piles and vegetation a few feet above the water. At dusk, some individuals may reach a pond and begin the breeding song while others, who were farther away, are still voicing the barking call. Therefore, for a short while at dusk one may hear the breeding call from a pond and also the barking call from nearby trees.

Throughout most of the day the frogs seemingly remain stationary in the trees, and bark only 10 or 15 times during a 13-hour period; but as they approach the breeding pond at dusk, they may bark 8 or 10 times during the four or five minutes required to reach the pond.

One breeding pond may be frequented each night for as long as three months, if the weather remains rainy. During this period the frogs, or at least some of them, do not return to the trees by day, but instead burrow into damp sand beneath logs and grassy tussocks around the pond border.

As the barking call involves an elaborate and well defined behavior pattern, it must serve some function. It is not a distress call like that of certain *Rana*, for I never saw any predator at the spots from which the calls seemed to emanate. Furthermore, the frogs tend to answer each other, and I have watched captive examples as they answered nearby wild ones or barked of their own accord. The tree call is evidently of social import, but I do not believe it is "advertisement" associated with territoriality. The barking call is given from the same spot throughout the summer, but there is no indication of social aggressiveness or defense of an area. The spatial distribution of the barkers is irregular and unpredictable. Frogs that answer each other may be just a few feet apart on the same limb (to judge from the sound), or may be at least 300 feet apart in different trees and on opposite sides of the breeding pond.

The barking call might serve to keep the individuals aware of each other, or oriented with respect to each other and to the breeding pond (about which they are distributed at varying distances). It will be recalled that Frog No. 1, which was closest of all to the pond, at dusk left

its treetop home, approaching the pond rapidly and as directly as the vegetation permitted, and leaping into the water from a surprising height. Obviously it "knew" the location of the breeding pond, or was drawn there perhaps by some hydro-positive reaction. (Many authors have shown that treefrogs react to humidity gradients.) This frog, which could find the pond, barked while en route thereto, and so frequently that I could trace its path by the sound. It seemed likely that other individuals, which had to find the pond from distances of about 70 to 200 feet, were aided in this activity by the barking of Frog No. 1.

The barking call may be an example of cooperation, on an instinctive level.—WILFRED T. NEILL, Research Division, Ross Allen Reptile Institute, Silver Springs, Florida.

SUBSPECIFIC IDENTITY OF *RANA SYLVATICA* IN MISSOURI. Cope (1889, Bull. U. S. Nat. Mus., 34: 437) listed four specimens of *Rana cantabrigensis* (USNM 3457) as collected by R. P. Hoy in western Missouri. Hurter (1911, Trans. Acad. Sci. St. Louis, 20: 123) restricted this record to Cooper County, apparently on the basis that this was the only place that Hoy (1865, Journal of an Exploration of Western Missouri in 1854, Ann. Rept. Smith. Inst. for 1864: 433) mentioned taking the form. Breukelman and Smith (1946, Univ. Kansas Mus. Nat. Hist. Publ. 1(5): 105) in reporting a single specimen of *Rana sylvatica cantabrigensis* from Lyon County, Kansas, have expressed the belief that the early allocation of Hoy's specimens was correct, and that the Wood Frog is represented in Missouri by two subspecies, *sylvatica* and *cantabrigensis*.

Hoy's old specimens were sent to the author through the courtesy of Dr. Doris M. Cochran. Three are *pipiens*; the largest is *palustris*!

Consequently, *Rana sylvatica* is known in Missouri from only Stone County and the vicinity of St. Louis (1 spec. USNM 3453, collected by George Engelmann). The latter record has yet to be verified. Hurter and more recent workers have not collected the species in eastern Missouri although it is known from western Illinois. The southwestern Missouri population is *Rana s. sylvatica* Le Conte.—CHARLES W. MYERS, 3154 N.W. 10th St., Gainesville, Florida.

TRUE TYPE LOCALITY OF THE SALAMANDER *GYRINOPHILUS PORPHYRITICUS INAGNOSCUS*.—The type locality of this salamander is given by Mittleman (Proc. New England Zool. Club, 1942, 20: 27) as "Salt Creek, 4 miles southwest of Bloomingville, Good Hope Township, Hocking County, Ohio." Dr. Doris M. Cochran, Curator of Reptiles and Amphibians,

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United States National Museum, writes that the data on the type specimen (USNM 115520) is the same as in the description. However, Salt Creek does not flow through Good Hope Township; there is no Bloomingville in Hocking County, but a town by the name of South Bloomingville. A locality on Salt Creek, 4 miles southwest of South Bloomingville would be in Salt Creek Township. To make the location concise I restrict the type locality to the following area: Salt Creek, 4 miles southwest of South Bloomingville, Salt Creek Township, Hocking County, Ohio.—JOHN M. CONDIT, 353 East Lincoln Ave., Columbus 14, Ohio.

ANOTHER INDIANA RECORD OF *CEMOPHORA COCCINEA* AND A NOTE ON EGG-EATING.—The scarlet snake, *Cemophora coccinea* Blumenbach, uncommon in the north central part of its range, has been reported from localities in Kentucky (Hibbard, 1936, Trans. Kans. Acad. Sci., 39: 281), Illinois (Bennett, 1953, Herpetologica, 9: 164), and Indiana (Minton, 1944, Amer. Midland Nat., 32: 453). The Indiana record is based on a specimen collected 4 miles west of New Albany in 1935.

On May 25, 1957 an adult scarlet snake was found under an embedded rock slab on an open, rocky hillside of the Bald Knobs about five miles north of New Albany. The following day a juvenile specimen was collected in a similar situation on a hillside about  $\frac{1}{2}$  mile north of the first. (Specimens deposited in the University of Michigan Museum of Zoology and in the private collection of the senior author). This part of the Bald Knobs is sparsely wooded chiefly with chestnut oak (*Quercus montana*) and blackjack oak (*Q. marilandica*). Characteristic plants of the bare, open hillsides include huckleberry (*Vaccinium corymbosum*), false aloe (*Agave virginica*), and wild sweetpea (*Tephrosia virginiana*). The scarlet snakes were collected a few hours after a series of heavy thunder showers; the normally dry soil of the hillsides was thoroughly soaked. Small, secretive snakes were observed in the greatest numbers ever encountered in this locality during some 25 years collecting. In addition to the 2 *Cemophora*, 4 southeastern crowned snakes (*Tantilla c. coronata*), 2 northern ringneck snakes (*Diadophis punctatus edwardsii*), and at least 6 midwest worm snakes (*Carphophis amoena helena*) were found during searches lasting no more than 4 hours.

The finding of these snakes draws attention to the interesting fauna present on the bare slopes at the southern end of the Knobstone Escarpment in Indiana. The southeastern crowned snake, *Tantilla c. coronata*, seems restricted to this habitat in the state, and the six-lined racerunner,

*Cnemidophorus sexlineatus*, is known in recent times from no other locality in southern Indiana. This is also the only known Indiana locality for the large trap-door spider, *Ummidia (Pachylomerides) audouinii*.

Dickson (1948, COPEIA, (3), 216-17) reported that the eggs of box turtles were punctured by *Cemophora* and the contents ingested. Our largest Indiana specimen (total length 357 mm.) was kept in a gallon glass jar containing about an inch of sand mixed with rotten wood. On May 31 at about 6 PM the egg of a corn snake (*Elaphe g. guttata*) was placed in the container. This egg, laid the previous day, measured 30 mm. in greatest diameter. At 9:30 PM the egg had not been touched. The next morning, however, the egg was found partly collapsed and covered with sand grains. The shell was normally flexible and the egg contents fluid. At one end were 2 fine slits about 3 mm. in length.

On June 9 another corn snake egg was placed with the *Cemophora*. This egg had been laid May 11 and was 46 mm. in greatest diameter. It had been attacked by mold and had a brownish, solidified spot at one end. This egg remained with the scarlet snake 4 days but was not disturbed by the reptile in any manner. On June 16 a third corn snake egg from the clutch laid May 30 was offered. This egg measured 44 x 20 mm. and was normal in appearance. At 4 AM the following morning, this egg was found partly collapsed. It had been virtually encircled by a series of 10 slightly curved slits 2 to 5 mm. long. At one end were 2 similar slits with the egg contents exuding from them. This egg was left with the snake the succeeding 2 nights but was not disturbed further.

Snouts of 3 preserved *Cemophora*, including a large Florida specimen, were examined. No specialized structures for cutting or piercing could be seen on the rostral. It is our impression that the cuts in the egg shells were made by the snake's teeth. At least one of the snakes observed by Dickson (*op. cit.*) had its head inside a turtle egg. If our specimen fed in this manner, it was very neat about it. This method of feeding upon reptile eggs too large to swallow is known for no other snake. It is a performance almost as remarkable as the egg-eating of *Dipsaspeltis*.—SHERMAN A. MINTON, JR. AND H. B. BECHTEL, Indiana University Medical Center, Indianapolis, Indiana and 3359 Meadow Court, The Meadows, Indianapolis, Indiana.

THE OCCURRENCE OF THE PICKEREL FROG, THREE SALAMANDERS AND TWO SNAKES IN MISSISSIPPI CAVES.—*Rana palustris*, the pickerel frog, has been reported in Tennessee caves (Bart, COPEIA 1953 (1): 60-61) and in

an Alabama cave (Brown and Boschung, COPEIA 1954 (3): 226). I have taken this frog from 3 caves in Mississippi.

A cave west of Gallman, Copiah County, southwestern Mississippi, has a sandstone cap and walls and floors of soft clay. It extends back under the bank of Turkey Creek for about 12 yards and averages four feet in height and five feet in width. This cave lies in the Catahoula formation of the Miocene. I visited this cave about eight times during July and August, 1956, and several times since. Pickerel frogs were always present; on one trip I saw 27 and collected eight. Some of these were in burrows in the walls of the twilight zone. These burrows, about 6 inches across at the mouth and four to five feet in depth, must have been made by some other animal. Here the frogs exist in total darkness.

About 50 times during the past 5 years I have entered Pitts Cave, a limestone cave near Waynesboro, Wayne County, southeastern Mississippi. *Rana palustris* has been encountered each time. The cave has two entrances approximately 500 yards apart; each entrance measures about 12 feet by 10 feet. The rooms and passageways in some places are about 15 feet high. A small spring creek flows through the cave. *Rana palustris* can be found along the ledges and among the many stalactites and stalagmites within the twilight zone. I have found no other anurans in the cave, although I have collected *Rana pipiens sphenocephala* in the entrance. The following salamanders have been found: *Eurycea longicauda guttolineata*, *Pseudotriton ruber vioscai*, *Plethodon glutinosus glutinosus*. These occur far beyond the twilight zone, and some were collected about one-quarter of a mile from the entrance.

Carter's Cave near Eucutta, Wayne County, Mississippi, extends under the bank of a creek for about 100 yards. The entrance is about four feet high and is gradually being filled in by slide rock above the mouth. A small spring creek flows out of the cave. I have visited it about 50 times in the past five years and always encountered *R. palustris* in the twilight zone. No other frogs were met but the salamanders listed above were found as far as 100 yards from the entrance. These two caves lie in Glendon limestone (Vicksburg-Oligocene) of the Gulf Coastal plain. In fact the whole of Mississippi lies in the Gulf Coastal plain except for a few acres in the very northeast corner.

The three species of salamanders are the most common amphibians of the caves of south central Mississippi. I have never seen them in any but limestone caves. *Rana palustris* is the only cave-dwelling frog I have found.

My observations indicate that these frogs leave the caves at night and are often abundant in the

general vicinity of the caves. During extremely warm weather they are not active and occur mostly in caves, or outside the caves in the crevices of rocks, or in creek beds. They are active in damp, cool periods during and following rains. In winter *Rana palustris* always is present in the three caves; they may be buried or under rocks, in crevices, and in the sand. Wright and Wright (Handbook of Frogs and Toads, Comstock Pub. Co., New York, 1949, p. 478) stated, "They hibernate in water." A large portion of the Mississippi populations may hibernate in dark, damp recesses rather than in water. In winter I have not found them in creek beds near the caves.

On August 14, 1956 I took a 21-inch *Elaphe guttata guttata* and an 8.5-inch *Diadophis punctatus stictogenys* in Pitts Cave. The floor rises sharply from the entrance and then descends. Therefore, the twilight zone is about 20 yards in extent. The two snakes were found about 50 yards beyond the twilight zone on opposite walls of the cave. The *E. g. guttata* disgorged three large cave crickets (*Cunthophilus gracilipes*).—W. E. BRODE, *Gulf Coast Research Laboratory, Ocean Springs, Mississippi.*

PREHENSILITY OF THE TAILS OF TWO

**TURTLES (FAMILY CHELYDRIDAE).**—The turtles *Macrochelys temmincki* and *Chelydra serrapinta* have a tendency to curl their tails beneath the carapace when molested. By tapping the posterior part of the plastron with a pencil, I have found that turtles of both species could be induced to grasp a stick or broom handle with the tail and thus could be raised off the ground where they would hang from a few seconds to several minutes.

Approximately 15 trials with each species were made. Three specimens of *C. serpentina*, weighing approximately 4, 8, and 12 pounds, were used. The 2 specimens of *M. temmincki* used weighed approximately 4 and 8 pounds.

Carr (Handbook of Turtles, Cornell Univ. Press, 1952) quoted a manuscript of Ross Allen and W. Neill which states that large *M. temminckii* should not be carried by the tail, because large specimens may later die from injury to the tail vertebrae. Large specimens may not be able to suspend their own weight by the prehensile tail. It is quite probable, however, that larger turtles as well as small ones possess the ability to hang suspended by their tails from tree limbs and logs in the water of quite swift streams.—W. E. BRODE, Gulf Coast Research Laboratory, Ocean Springs, Mississippi.

COMMENTS ON THE TYPE LOCALITY  
AND GEOGRAPHICAL DISTRIBUTION OF  
*UROSAURUS GADOWI*—Schmidt (1921). Amer.

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Through Grandison's (1960) study I received his collection and a list of the Museum types from *Uroplatus* and other species of *Uroplatus*, *daedalus*, *garamaso*, *Hypopachus*, *lateralis*, *Anolis*, *nebulosus*, *ligaster*, *Pholidoscelis*, *Leptodeira*, *Leiocephalus*, *In the genus*, *Sceloporus*, *Cnemidophorus*, *C. sackii* and *C. lowlandi* which do not occur in

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Mus. Novitates, 22: 3-4) described *Urosaurus gadowi* on the basis of specimens collected by Hans Gadow. The type locality was given as Cofradia, Jalisco, México. Subsequently the species was reported from Apatzingán, Michoacán, by Littleman (1942, Bull. Mus. Comp. Zool., 91(2): 155), from Acahuato, Michoacán, by Schmidt and Shannon (1947, Fieldiana: Zool., 31(9): 71), and from La Playa and Volcán Jorullo, Michoacán, by Duellman (1954, Occ. Papers Mus. Zool. Univ. Michigan, 560: 11).

During the course of field work in the Tepalcatepec Valley in southern Michoacán in 1955 and 1956, large series of *Urosaurus gadowi* were collected. Together with the material available in museums a total of 108 specimens was examined. All are from the low, arid valley of the Río Tepalcatepec, the largest tributary of the Río Balsas, or from the western part of the valley of the Río Balsas. With the exception of three individuals found at elevations of 3600 and 4100 feet on the slopes of Volcán Jorullo and one from 3700 feet near Ziracuaretiro, Michoacán, all have been collected at elevations ranging from 600 to 2600 feet. Many of the specimens have been collected at or near the village of Cofradia, Michoacán.

Through the courtesy of Miss Alice G. C. Grandison of the British Museum (Natural History) I received a copy of Gadow's map showing his collecting localities in southwestern México and a list of Mexican specimens in the British Museum that were collected by Gadow. Aside from *Urosaurus gadowi*, he collected the following species at Cofradia: *Bufo marinus*, *Leptodactylus labialis*, *L. melanotus*, *Hyla baudini*, *Hypopachus oxyrrhinus*, *Phyllodactylus lanei*, *Anolis nebulosus*, *Sceloporus melanorhinus caligaster*, *Phrynosoma asio*, *Hypsiglena torquata*, *Leptodeira smithi*, and *Trimorphodon biscutatus*. In the general region of Cofradia I have also collected: *Ctenosaura pectinata*, *Enyaliosaurus clarki*, *Sceloporus horridus oligoporus*, *S. pyrocephalus*, *Cnemidophorus calidipes*, *C. deppei* subsp., and *C. sacki copei*. All of these are characteristically lowland in their distribution and generally do not occur at elevations of more than 4000 feet.

By following Gadow's travels in southern México as outlined in his books (1908, *Through Southern Mexico*, and 1930, *Jorullo*) and his map, it is evident that he was in the vicinity of two villages named Cofradia. He collected reptiles and amphibians at Cofradia, Michoacán, and refers to that village many times in his book on Jorullo. During his travels from Mexico City to Nevado de Colima he may have passed through or close to Cofradia, Jalisco. This small cluster of huts is situated on the Jiquilpan-Colima road about two miles southwest of Mazamitla at an elevation of about 5600 feet. The village is in a

pine forest having an understory of scrubby bushes. A short stop in this area in 1956 revealed no herpetological specimens; it definitely is not an area that would be inhabited by the species known from the vicinity of Cofradia, Michoacán. Consequently I feel that the type specimen of *Urosaurus gadowi* was mislabeled as to state and actually came from Cofradia, Michoacán, and not the village of the same name in Jalisco. Cofradia is a common place name in western México; there are other villages with this name in Michoacán and Jalisco, but they are not in the area in which Gadow traveled, nor are they in an area in which species of reptiles living with *U. gadowi* occur.

The range of *Urosaurus gadowi* therefore is restricted to the arid Tepalcatepec-Balsas Basin in Michoacán, a region to which *Cnemidophorus calidipes*, *Enyaliosaurus clarki*, and *Eumeces altamirani* also are endemic.

Field work in México was supported in part by the Museum of Zoology, University of Michigan, and by a grant from the Penrose Fund of the American Philosophical Society. This is contribution No. 9 from the Department of Biology, Wayne State University, Detroit 2, Michigan.—WILLIAM E. DUELLMAN.

A RECORD OF *HEMIDACTYLIUM SCUTATUM* IN FLORIDA.—A four-toed salamander was collected by Lovett Williams north of Tallahassee, March 3, 1955. The exact locality was near the Ochlockonee River, on the Leon County side, approximately one-half mile west of the Old Bainbridge Road, six miles from the Georgia line. Concerning the southern limits of the range, Schmidt (Check List of North American Amphibians and Reptiles, 1953) stated "... west of the Appalachians to Alabama and Arkansas; an isolated area in South Carolina and northeastern Georgia." This record represents an extension of 300 miles in the range. The identity of the specimen was checked by Dr. Ralph Yerger, Florida State University (the present location of the specimen), and Dr. William J. Riener, University of Florida.—HENRY M. STEVENSON, Biological Sciences Department, Florida State University, Tallahassee, Florida.

A DELETION OF DISTRIBUTION RECORDS OF *HYLA SQUIRELLA*.—Recent inquiries by Roger Conant and Glenn Gentry have prompted the author to re-examine the specimens on which the records of *Hyla squirella* in Kentucky are based (Barbour, Roger W., COPEIA 2: 128, 1942; Am. Midland Nat. 44 (3): 759-760, 1950; Trans. Ky. Acad. Sci. 17(2): 81-86, 1956).

The specimens are *Pseudacris nigrita*; their identification has been verified by Phillip W.

Smith. *Hyla squirella*, therefore, is not currently known to occur in Kentucky.—ROGER W. BARBOUR, Department of Zoology, University of Kentucky, Lexington, Kentucky.

NOTES ON THE HERPETOLOGY OF THE DELMARVA PENINSULA.—Because of the recent discovery of *Gastrophryne* on the Delmarva Peninsula, the appearance of an erroneous statement concerning the status of *Cemophora* in the area, and the accumulation of other information, I have assembled the following notes. The Delmarva Peninsula may be defined as consisting of Delaware and the Eastern Shore portions of Maryland and Virginia, and extending from the Pennsylvania border southward to Cape Charles. I have recently commented upon range extensions within the Peninsula for *Natrix e. erythrogaster* (1955, Nat. Hist. Misc., 147: 1-2) and *Pseudotriton m. montanus* (1957, COPEIA: 152). For assistance in the preparation of this paper I am indebted to John E. Cooper, James A. Fowler, Robert A. Littleford, Edmond V. Malnate, Albert Schwartz, Charles J. Stine, Willis L. Tressler, Charles A. Triplehorn, and Peter Wemple.

*Hyla cinerea cinerea* × *evittata*.—Charles A. Triplehorn collected a frog of this complex on the Bombay Hook Wildlife Refuge, east of Smyrna, Kent County, Delaware, on May 17, 1954, and thus extended the range northward on the eastern side of the peninsula by approximately 60 miles. The nearest previously reported locality from along the Atlantic side of Delmarva is in the extreme southeastern corner of Delaware. Five specimens, which I have been privileged to examine and measure through the courtesy of Francis Harper, were collected two miles northwest of the Fenwick Island lighthouse in Sussex County, Delaware, on July 29, 1954, by Dr. Harper, Richard Pough, Robert K. Enders, and A. Enders. (On the western side of the Peninsula this frog has long been known from near the head of Chesapeake Bay in the vicinity of the terminus of the Chesapeake and Delaware Canal.) Triplehorn was told by members of the staff of the Bombay Hook Refuge that they had seen other green treefrogs in the general vicinity. His specimen was taken during daylight hours on a cattail stalk in an inundated area that was in the process of being reclaimed from salt marshes. It is an adult female containing large, nearly mature (?) eggs and measuring 44.5 mm. in snout-vent length. The light lateral stripe terminates at about midbody. It has been deposited in the American Museum collection (AMNH A60341).

Reed (1956, Jour. Washington Acad. Sci., 46: 328-32) expressed the opinion that *Hyla cinerea*

is monotypic and that the name *evittata* should be suppressed. He based this opinion on material from Maryland, Delaware, and Virginia in his personal collection and in that of the United States National Museum. He did not report upon specimens from other parts of the range of *cineraria*. A thorough and careful study of this complex may eventually prove that *Hyla cinerea* is indeed monotypic. Meanwhile, I consider Reed's work inconclusive and I follow the suggestions of Dunn (1937, Proc. Biol. Soc. Washington, 50: 10), who interpreted the Delmarva population of these frogs as being intermediate between *cineraria* and *evittata*.

*Gastrophryne carolinensis* (Holbrook).—The eastern narrow-mouthed toad was first recorded from Maryland by Noble and Hassler (1936, COPEIA: 68) who found it in the vicinity of Cove Point, Calvert County. Subsequently the species has been collected or observed at Cove Point by a number of persons (Hardy, 1953, Herpetologica 8: 162). Fowler and Stine (1953, Herpetologica 9: 167) added a second county, St. Marys, by reporting a specimen from "along the floodplain of the St. Marys River just northeast of Great Mills P. O." Both their locality and Cove Point are on the mainland, or Western Shore, portion of Maryland.

It is now possible to add another Maryland locality, but this time from the eastern side of Chesapeake Bay! Peter Wemple, a resident of St. Michaels, Maryland, collected a specimen of *Gastrophryne* at Taylor's Island, Dorchester County, on May 23, 1957. Wemple's account of the incident is as follows: "The toad was taken at night with the aid of a flashlight and it was momentarily mistaken for a cricket frog, but the light glinted on the neck fold. It was in the open at the very edge of a small pool in a bog area that was nearly dry as the result of drought conditions. This is a narrow woodland bog nearly a half mile long and occupying what seems to have been a former drainage ditch. The surrounding terrain is flat and very close to sea level. The woods is mainly oak and loblolly pine, typical of southern Delmarva."

Wemple had heard a strong chorus of what he thought was *Gastrophryne* at the same locality during the previous July.

The specimen is a male (throat very dark, no dissection made), measuring 24.5 mm. in snout-vent length and is now catalogued as A60339 in the collection of the American Museum of Natural History.

The new locality, although on the opposite side of Chesapeake Bay, is only about nine miles northeast of Cove Point. Taylor's Island, which is approximately six miles long in a north-south

direction adjacent to the "islands" which are the main channels. The baywise erosion, a partial in as yet not in slightly such as the (cit.) for C suggest su has comm *Gastrophryne* all known are near c It is likely found in o a search i season mig

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direction and three miles wide (including the adjacent Hooper Neck), is one of the numerous "islands" and "necks" that border the bay and which are separated, in whole or in part, from the mainland of the Eastern Shore by open channels or marshes of salt or brackish water. The bayward side of the area is subject to wave erosion, and its lower portions may even suffer partial inundation during severe storms. There is as yet no evidence that *Gastrophryne* may breed in slightly brackish ponds on Taylor's Island, such as those reported by Noble and Hassler (*loc. cit.*) for Cove Point, but the environment would suggest such a possibility. Hardy (*op. cit.*, p. 163) has commented upon the occasional association of *Gastrophryne* with haline habitats. In any event, all known localities for this species from Maryland are near or directly adjacent to Chesapeake Bay. It is likely that the narrow-mouthed toad will be found in other places on the Delmarva Peninsula; a search in bay shore areas during the calling season might prove profitable.

*Rana virgatipes* Cope.—Reed (1957, *Herpetologica*, 13: 137), stated that (after 1947) "no further collections of this frog have been recorded from either Delaware or Maryland," and he implied that the species is rare on the Peninsula. For the benefit of students of anurans, attention must be called to a paper that Reed overlooked and in which Meanley (1951, *Proc. Biol. Soc. Washington*, 64: 59) reported the carpenter frog from two areas in Maryland and one in Delaware. This species is still locally common, especially in portions of the Great Cedar Swamp that once occupied some 50,000 acres in extreme southern Delaware and adjacent Maryland. Although the great forest of *Chamaecyparis* and *Taxodium* has long since disappeared, the region remains swampy and sphagnaceous and large choruses of *R. virgatipes* may be heard there in late spring.

*Clemmys insculpta* (Le Conte).—There is now abundant evidence to indicate that the wood turtle is indigenous to Elk Neck and the Susquehanna River valley in Cecil County, Maryland. The Natural History Society of Maryland has several specimens from that area; others have been deposited in the collections of the American Museum (AMNH 69045) and the Museum of Zoology at the University of Michigan (UMMZ 99002). This species was not included in the Delmarva checklist (Conant, 1945, *Soc. Nat. Hist. Delaware*: 1-8), and McCauley (Reptiles of Maryland and the District of Columbia: fig. 39) had no records from the Eastern Shore.

Virtually every state or sizable geographic area is plagued with an accumulation of dubious herpetological "records" that cannot be substantiated even after diligent collecting. These are

usually based upon misidentifications or hearsay evidence or upon the finding of escaped or liberated specimens. Compilers of mere lists or those who are unfamiliar with the fauna of a region tend to repeat such unproved records, thus often obscuring our knowledge of species distributions. Progress is better served, in my opinion, by discarding these from faunal listings. A case in point involves the *Clemmys insculpta* reported by Reed from Easton, Talbot County (1956, *Herpetologica*, 12: 80)—this same paper was repeated virtually verbatim on page 136 of the next number of the same journal. His report is based upon a specimen in the collection of the Natural History Society of Maryland (NHSR R-529) found four and one-half miles west of Easton on September 9, 1939. There is no evidence of a naturally occurring population of the wood turtle on the Delmarva Peninsula south of Elk Neck, and it would seem best to discount the Easton locality in view of the propensity of human beings, young people especially, to transport turtles and liberate them far from their natural habitats. McCauley (*op. cit.*: 155) concurs in this opinion.

*Lygosoma laterale* (Say).—The first, and so far only, specimen of this lizard from Delaware was found under bark near a small sawdust pile approximately four miles north of Georgetown, Sussex County, May 16, 1948, by Edmond V. Malnate and Laird Starr. It has been given to the American Museum (AMNH 77548).

*Haldea valeriae valeriae* (Baird and Girard).—This snake was first reported from "Delaware" by Stone (1906, *Amer. Nat.*, 40: 164), as *Virginia valeriae*. Two detailed localities may now be recorded for that state: (1) One specimen found under a rotting board at Ellendale, Sussex County, April 29, 1946, by Richard Knox, Robert Teeters, Robert G. Hudson, and myself, and now in the Carnegie Museum (CM 26178); and (2) four specimens taken under large pieces of asphalt sheeting near a woods about two miles southeast of Glasgow, New Castle County, April 17, 1953, by Charles A. Triplehorn, and now in the collection of the Ohio State Museum.

*Cemophora coccinea* (Blumenbach).—There has been confusion concerning the occurrence of the scarlet snake on the Delmarva Peninsula. McCauley, in his *Reptiles of Maryland* (*op. cit.*: 101), stated "it has not yet been taken on the Eastern Shore," but on the same page he contradicted himself by listing it from Salisbury, Wicomico County. This *lapsus calami* was occasioned, no doubt, by my writing to him, while his paper was in press, about a Salisbury specimen that had been found in the University of Maryland collection. In adding the locality, presumably on his galley proof, he inadvertently

forgot to delete the statement about the absence of *Cemophora* from the Eastern Shore. Unfortunately he ascribed the record to me and did not include the additional information I supplied to him in correspondence.

Fowler (1945, Proc. Biol. Soc. Washington, 58: 89) was the first to point out the true source of the Salisbury record. Littleford (1955, Herpetologica, 11: 104) cited both the McCauley and Fowler papers, and quite understandably stated that "it should be noted also that the record from Salisbury apparently represents two different collections." His inference was that one specimen had been collected by me and that there had been another *Cemophora* in the Maryland collection; actually both reports were based upon the same snake. Littleford also mentioned that the specimen was absent from the collection.

In two mimeographed lists (1956, Contributions to the Herpetology of Maryland and Delmarva, no. 8, p. 19, and no. 11, p. 8), Reed, through a process of reasoning that I fail to follow, stated categorically that "there are no specimens of this snake from Wicomico County, and the snake is not known from the Eastern Shore or Delmarva."

Despite all this confusion and Reed's unfortunate misstatement, there is indeed a specimen of *Cemophora coccinea* from Delmarva. It was obtained near Salisbury during April, 1923, and was sent by J. P. Brown, (Wicomico) County Agent, to the University of Maryland for identification. It was catalogued as No. 1 in the Maryland herpetological collection.

During the preparation of my check list of the amphibians and reptiles of the Delmarva Peninsula (Conant, *op. cit.*), I borrowed the specimen for study, but, when I wrote to its custodian at the University of Maryland, announcing my in-

tention of returning it, I received no reply. Because of the exigencies of the war years, with their disturbance of personnel, I presumed that the custodian had been transferred or gone off to war. Lest the specimen should arrive at College Park and be unattended for some time, I stored it instead with a series of *Cemophora* from southern New Jersey in the temporary study collection that is maintained at the Philadelphia Zoo. There it remained until I searched for it recently after reading the Littleford paper.

Dr. Robert A. Littleford and Dr. Richard Highton, both of the Department of Zoology of the University of Maryland, have suggested that the snake be deposited in one of the large museums instead of being returned to their own institution. Accordingly it has been presented to the American Museum of Natural History and is now AMNH 77104. It is a female measuring 541 mm. in total length; tail 79 mm. There are 19 scale rows throughout the length of the body, 162 ventrals, 39 pairs of subcaudals, 6 supralabials, 7 infralabials on the left and 8 on the right, one preocular, one postocular on the left and 2 on the right, temporals 1-2 (on the right side of the head the anterior temporal is fused with the upper temporal of the 2nd row). There are 14 reddish, black-bordered blotches on the body and 5 similar but smaller blotches on the tail. Mr. J. P. Brown, the donor of the snake and to whom I addressed an inquiry many years ago, was unable to supply any detailed collecting data.

To the best of my knowledge this is the only specimen of *Cemophora* extant from the Delmarva Peninsula.—ROGER CONANT, Zoological Society of Philadelphia, Philadelphia 4, Pennsylvania.

## Ichthyological Notes

THE STATUS AND SYNONYMY OF THE EASTERN PACIFIC EEL *ARIOSOMA GILBERTI* (OGILBY)—The specimens on which *Ariosoma gilberti* is based were recorded by Gilbert (1892) from Albatross Station 2797 (Bay of Panama) as *Ophisoma balearicum*? De La Roche. He also included under this heading a specimen recorded from Cape San Lucas by Jordan and Gilbert (1883) as *Leptocephalus conger* Linnaeus. Ogilby (1898), in his synopsis of the species of *Congrellus* (= *Ariosoma* Swainson), proposed the new name *Congrellus gilberti* for these specimens, distinguishing the species

from the Atlantic form *Congrellus balearicus* on the basis of Gilbert's description. Owing to the circumstances involved in the naming of *Ariosoma gilberti*, no type has ever been designated. I hereby designate as the lectotype USNM 44923, a specimen 138 mm. in standard length, from Gilbert's Panama material. Two specimens of 112 mm. and 128 mm. standard length (USNM 125091), from the same collection as the lectotype, are designated as paratypes.

Meek and Hildebrand (1923) redescribed *Ariosoma balearica*, basing their description on the specimen here designated as the lectotype of *A.*

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*gilberti*, and on one specimen from Cuba. As the description stands, it is impossible to determine to which specimen the various parts refer. There are, however, important discrepancies between the descriptions of Gilbert and that of Meek and Hildebrand which must be resolved. Mr. Robert Kanazawa of the United States National Museum has kindly re-examined the lectotype of *A. gilberti*.

He records the following data for several diagnostic characters concerning which the descriptions of Gilbert and of Meek and Hildebrand are at variance: *maxillary dentition*—"Anteriorly there are three irregular rows of teeth which narrows to two and then one row posteriorly"; *relative size of gill slits and isthmus*—"Isthmus measures 3.5 mm. Gill opening (measures) 3.5 mm.;" *position of dorsal origin*—"Origin of dorsal 1.4 mm. anterior to insertion of pectoral fin" (The insertion of the pectoral is at the upper angle of the gill slit); *position of the anus*—"Distance from tip of snout to anus 65 mm. Total length 138 mm. Snout length 5.3 mm." (Tail longer than head and trunk by .8 mm., or .31 head lengths); *coloration*—"black pigment spots are present to form a short bar under the eye." These data agree with Gilbert's description in every character but that of the position of the anus, and disagree with that of Meek and Hildebrand in every character but that of the position of the anus.

I have examined 31 specimens of *Ariosoma gilberti*, 28 from the Gulf of California, one from southern Mexico, one from Guatemala, and one from Colombia. This material agrees well with the lectotype, except for the relative length of the tail. This character is subject to much individual variation. In my material, the tail is longer than the head and trunk by a distance ranging from .8 to .31 head lengths. In the lectotype the tail is longer than the head and trunk by a distance equal to .31 head lengths. Part of the apparent wide range of variation is due to a relative shortening of the tail with increasing size.

In light of this re-evaluation of the characters of *Ariosoma gilberti*, it became apparent that the status of *Ariosoma vomerina* Myers and Wade 1941 and *Thyreociong hemiaspidus* Wade 1946 was in need of clarification. Through the courtesy of Dr. John Garth and Miss Janet Haig of the Allan Hancock Foundation of the University of Southern California, I have been able to examine the type specimens of these species.

According to Myers and Wade, *A. vomerina* differs from *A. gilberti* in that the tail is longer than the rest of the body by a length greater than

the head, the isthmus is narrower than the gill openings, and in details of dentition.

Several discrepancies were found between the holotype and the description given by Myers and Wade. The most important of these are presented in table I. There are additional differences. The isthmus is very nearly equal to the gill openings, which are equal to about  $\frac{1}{3}$  of the eye. The maxillary teeth are not in a single irregular series as described, but are in three irregular rows anteriorly, which narrow to two and then one irregular row posteriorly. The figures of the type are untrustworthy, duplicating many of these errors and exaggerating some.

Myers and Wade include no discussion of comparative material in their treatment, evidently utilizing only the description given by Meek and Hildebrand. That it was the description of Meek

TABLE I  
MEASUREMENTS IN MM. OF HOLOTYPE OF *A. vomerina*.  
COLUMN A FROM MYERS AND WADE (1941), COLUMN  
B, MEASUREMENTS TAKEN IN FEBRUARY, 1956.

	A	B
Standard length	99.0	103.0
Head and trunk	41.0	44.9
Tail	58.0	56.4
Head	14.0	15.9
Snout	3.0	3.3
Eye	2.5	3.0
Cleft of mouth	3.5	5.3
Depth	6.0	5.0
Length gill opening	5.0	2.4
Width isthmus	2.0	2.0

and Hildebrand which was used, rather than that of Gilbert, is indicated by the fact that the characters of *A. gilberti* mentioned in their key and discussion appear to have been taken verbatim from the former treatment.

Most of the differences mentioned by Myers and Wade do not hold if the redetermined measurements of the holotype of *A. vomerina* are compared with the original description of *A. gilberti* rather than with the misleading account given by Meek and Hildebrand. The only remaining differences between *A. gilberti* and *A. vomerina* are those involving the vomerine teeth and the coloration. The difference noted by Myers and Wade in the shape of the vomerine tooth patch is more apparent than real. "Six to eight teeth at the head of the shaft of the vomer, followed by 3 to 4 small teeth on the shaft," (Myers and Wade) is but a more precise way of stating "vomerine teeth are arranged in an elongate triangular patch with a long posterior projection" (Meek and Hildebrand). The material of *A. gilberti* which I have examined is like the type of *A. vomerina* in

this character. With regard to coloration, Myers and Wade describe *A. vomerina* as "... very light cream, with no dark markings on the body, except minute black specks dorsally . . .," although the black bar beneath the eye so characteristic of *A. giberti* is definitely present. It is apparent in gross examination and may readily be seen under magnification as a dusting of melanophores under the eye. I have further compared the holotype of *A. vomerina* with specimens of *A. giberti* from the Gulf of California and can find no differences in any character.

The holotype of *Thyreoconger hemiaspidus* Wade 1946 was compared with the holotype of *Ariosoma vomerina* and specimens of *A. giberti* from the Gulf of California. It differed in no way from the material with which it was compared, agreeing perfectly in both generic and specific characters.

There is no basis for the retention of either *Ariosoma vomerina* Myers and Wade or *Thyreoconger hemiaspidus* Wade as species distinct from *Ariosoma giberti* (Ogilby). The genus *Thyreoconger* Wade follows its type species, *T. hemiaspidus*, and enters the synonymy of *Ariosoma* Swainson.

The history of *Ariosoma giberti* is summarized in the following synonymy:

*Ariosoma giberti* (Ogilby) 1898  
 1883 *Leptocephalus conger* not of Linnaeus. Jordan and Gilbert, Proc. U.S. Nat. Mus. 5(1882): 378. Description. Cape San Lucas.  
 1892 *Ophisoma balearicum* ? De La Roche. Gilbert, Proc. U.S. Nat. Mus. 14(1891): 349. Description. Panama, Cape San Lucas.  
 1892 *Congermuraena balearica* in part not of De La Roche. Jordan and Davis, Rep't. U.S. Comm. Fish. for 1888: 661. Description. Gilbert's record of 1892 wrongly attributed to Galapagos Islands.  
 1896 *Congermuraena balearica* in part not of De La Roche. Jordan and Evermann, Bull. U.S. Nat. Mus. 47(1): 356. Description, synonymy. Range error repeated.  
 1898 *Congrellus giberti* Ogilby. Ogilby, Proc. Linn. Soc. New South Wales. 28: 288. Name based on Gilbert's description.  
 1904 *Congrellus giberti* Ogilby. Gilbert and Starks, Mem. Cal. Acad. Sci. 4: 34. Name only.  
 1923 *Ariosoma balearica* in part not of De La Roche. Meek and Hildebrand, Field Mus. Nat. Hist. Zool. Ser. 15(1): 139. Description, synonymy. Range error repeated. Cuba, Panama.  
 1930 *Ariosoma giberti* (Ogilby). Jordan, Evermann and Clark, Rep't. U.S. Comm. Fish. for 1928(2): 80. Synonymy. Range error repeated.

1941 *Ariosoma vomerina* Myers and Wade. Myers and Wade, Univ. Southern Cal. Hancock Pac. Exp. 9(4): 68. Description, comparison with *A. giberti*. Port Utria, Colombia.

1946 *Thyreoconger hemiaspidus* Wade. Univ. Southern Cal. Hancock Pac. Exp. 9(7): 189. Description. Point Lobos Gulf of California (type locality), Chacahua Bay, Oaxaca Mexico, Point San Jose Guatemala.

#### Material Examined:

Fish collection, Department of Zoology, University of California at Los Angeles. UCLA numbers are collection numbers and not specimen numbers. Mexico, Sonora, Golfo de California. UCLA 50-57 Bahia Kino, 1(118 mm.); UCLA 52-8, Estero Soldado, 8(87-112 mm.); UCLA 52-51 Punta de las Cuevas, 1(113 mm.). Mexico, Sinaloa, Golfo de California- UCLA 56-118, 25 miles south of entrance to Bahia Topolobampo, 4(114-255 mm.). Mexico, Baja California, Golfo de California- UCLA 53-79, Bahia San Francisco, 9(115-175 mm.); UCLA 53-84, Bahia Santa Inez, 2(163-181 mm.); UCLA 53-95, Bahia Coyote en Bahia Concepcion, 1(125 mm.).

Fish Collection, Allan Hancock Foundation, University of Southern California. AHF 10. Velero Station 856-38, Colombia, Puerto Utria, 1(103 mm.). Holotype of *Ariosoma vomerina*. AHF 299. Velero Station 769-38, Guatemala, Punta San Jose, 1(103 mm.). Paratype of *Thyreoconger hemiaspidus*. AHF 310. Velero Station 767-38, Mexico, Bahia Chacahua, 1(105 mm.). Paratype of *Thyreoconger hemiaspidus*. AHF 461. Velero Station 725-37, Mexico, Sonora, Golfo de California, North of Punta Lobos, 1(158 mm.). Holotype of *Thyreoconger hemiaspidus*. Velero Station 675-37, Mexico, Sonora, Golfo de California, Punta Pulpito in 55 fathoms. 1.-RICHARD H. ROSENBLATT, Department of Zoology, University of California at Los Angeles, Los Angeles, California.

A LARGE WHITE SHARK, *CARCHARODON CARCHARIAS*, TAKEN IN MASSACHUSETTS BAY.—The capture of a white shark, *Carcharodon carcharias*, on July 19, 1957, within the Gulf of Maine is noteworthy for this shark, a species very dangerous to man, was the second largest to be reported from this part of our coast. A male, with large claspers, it measured 15 feet, 4 inches in length and 9 feet, 6 inches in girth and was estimated to have weighed about 3,000 pounds. It was exceeded in size only by one taken in a wier at Campobello Island in November 1932, judged to have been about 26 feet long. The shark was harpooned 3 miles east of Minot's Light, Massachusetts Bay by Mr. J. W. Lowes of North Scituate, Massachusetts, who in his report

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to us stated that "he put up quite a show, mostly on the surface, and did not sound until he was close in, bit the boat twice and got enough of a grip to score the planking pretty deeply and broke off a half dozen teeth. It took fifteen rounds of 30-30 to kill him."

After it was dead the shark was leveled alongside the boat so that its length and girth could be ascertained and then hoisted part way out of the water for removal of its jaws.

Mr. Lowes has a penchant for harpooning sharks, especially white sharks, and now has seven captures of the latter to his credit. Three of these, along with another taken by W. T. Reid, III, of Cohasset, all caught the summer of 1937 we previously reported (COPEIA 1938, No. 1, p. 46). White sharks must have been present within the Gulf of Maine that year in some number, rather than as strays, for two others were caught off Swampscott, Massachusetts in October (COPEIA 1939, No. 1, p. 48).

Other white sharks harpooned by Mr. Lowes are: August 24, 1938, east Cape Cod Bay, a female 7 feet, 9 inches long, 4 feet, 9 inches girth; September 13, 1947, near Boston Lightship, a female 4 feet, 9 inches long, 2 feet, 7 inches girth, the smallest white shark to come to our attention. It is in the collection of The Harvard Museum of Comparative Zoology. Our previous mention of this specimen as being 3 feet long (Fishery Bulletin of the Fish and Wildlife Service, Vol. 53, p. 26, 1953 was in error); July 16, 1956, 5 miles east of Minot's Light, a male, 8 feet, 8 inches long, 4 feet, 4 inches girth. In addition to these, Mr. Lowes reports that he ironed and lost four others identified with certainty.

All told, since 1930, there have been captured, or harpooned and lost, between 15 and 20 white sharks in Massachusetts and Cape Cod Bays, about 6 or 7 between Portland and the lower Bay of Fundy, and several along the outer coast of Nova Scotia.—HENRY B. BIGELOW AND WILLIAM C. SCHROEDER, Museum of Comparative Zoology, Cambridge, Massachusetts.

A REVERSED AMBICOLORATE SUMMER FLOUNDER, *PARALICHTHYS DENTATUS*.—An aberrant, female summer flounder, 265 mm. in standard length, was captured May 2, 1957, by the trawler EDRII M while fishing in four fathoms off Atlantic Beach, Carteret County, North Carolina. The specimen, presented to the University of North Carolina Institute of Fisheries Research at Morehead City, N. C., is deposited in the Research Fish Collection (UNC 1064).

Examination shows it to be a reversed, wholly ambicolorate individual. The eyes, normally

found on the left side of the head, are on the right. Coloration, normally confined to the left side, is almost equally developed on both sides with that of the left somewhat lighter.

The left or rotating eye has not completely migrated, but is located partially on the dorsal ridge. The dorsal fin extends over the incompletely rotated eye as a hook-shaped protuberance. The right pectoral fin, normally the shorter, is longer than the left.

Gudger (1936, Amer. Mus. Novitates, 896: 1-5, 3 figs.) reports upon a reversed, almost wholly ambicolorate summer flounder. His specimen lacked pigment on the left side of the head proper and on the hinder part of the left pectoral fin. Our specimen is colored in these areas, although pigmentation on the left pectoral is much less developed than on the right. In other respects, excepting size and details of coloration, Gudger's specimen is similar to ours.

Although ambicoloration in the summer flounder is of fairly frequent occurrence (Gudger, 1935, Amer. Mus. Novitates, 768: 1-8), we believe this to be the second record of reversal and ambicoloration in the same individual.

We wish to thank Mr. John Wegener of the University of North Carolina Institute of Fisheries Research and Mr. Ottis Purifoy, owner of the EDITH M, for making this specimen available.—EARL E. DEUBLER, JR., AND WILLIAM E. FAHY, University of North Carolina Institute of Fisheries Research, Morehead City, North Carolina.

COLORATION IN TEXAS HOGCHOKERS, *TRINECTES MACULATUS FASCIATUS*.—On April 11, 1956 the junior author collected a colorless *Trinectes maculatus fasciatus* (Lacépède), 75 mm. in standard length and 100 mm. in total length, with an otter trawl in Sabine Lake in waters of a salinity of 9.7 parts per thousand. Hubbs (1932, Proc. Biol. Soc. Wash., 45: 19-22) showed that the scientific name of the hogchoker should be *Trinectes maculatus* (Bloch), this having priority over the name *Achirus fasciatus* Lacépède.

The specimen differs from the typical form only in the lack of coloration on the right (eyed) side. The only pigment on the body is on the interradial membranes of the median fins and on a small area anterior to the caudal fin on both sides of the body. The pigment on the caudal region of the blind side is smaller in extent than that of the eyed side and is somewhat similar to that of normally colored specimens from Texas. The head is colorless except for the normally pigmented eyes and for a few chromatophores around the eyes.

Apparently lack of coloration is uncommon in the Achiridae as we find no record in American

forms. The specimen is in the collections of the Marine Laboratory of the Texas Game and Fish Commission in Rockport.

Jordan and Evermann (1898, Bull. U.S. Nat. Mus., 47 (3): 2701) stated that the blind side is always immaculate in the Gulf variety of this species (*T. m. fasciatus*). Chabanaud (1935, Bull. Inst. Oceanogr., 661: 10) distinguished the Gulf form, lacking ambicoloration, from the Atlantic form which is frequently ambicolorate. However, in six specimens in the collections of the A. and M. College of Texas (Cat. No. II-1-a-2) taken near Galveston, Texas, there is a varying amount of pigment present on the blind side, in one specimen covering the posterior one half of the body. This agrees with Atlantic specimens such as those described by Hildebrand and Schroeder (1927, Bull. U.S. Bur. Fish., 40(1): 175). Reid (1954, Bull. Mar. Sci. Gulf and Caribbean, 4(1): 66) took an ambicolorate *T. m. fasciatus* from Cedar Key, Florida.—HINTON D. HOESE AND CARL O. BERGLUND, JR., *Marine Laboratory, Texas Game and Fish Commission, Rockport, Texas.*

**POSITION OF ANAL FIN AND LENGTH OF BODY CAVITY IN CATOSTOMID AND CYPRINID FISHES.**—In "Fishes of the Great Lakes Region" (1949, Cranbrook Inst. Sci., Bull. 26: 24 and 45) Hubbs and Lagler pointed out that members of the sucker family (Catostomidae) may be distinguished readily from the minnows (Cyprinidae) by a superficial character, namely the more posterior anal fin: the distance from the origin of that fin to the caudal base is contained more, instead of less, than 2.5 times in the preanal length. It was further indicated, however, that in this respect the introduced carp, *Cyprinus carpio*, is like a catostomid. We were fully aware that many other extralimital cyprinids have the anal fin far back. The family key was obviously artificial and carries the reservation that it "will not apply to regions distant from the Great Lakes." The same warning was further stressed on page 2.

Overlooking this reservation and warning, Kafuku (1957, Jap. Jour. Ichth., 5: 163-73, figs. 1-3) dignified our family-separating character for Great Lakes Ostariophysi as the "morphological law on anal fin" and showed (as we were aware) that it did not apply consistently to Japanese cyprinids. Specifically, he indicated that the sucker-like Gobioninae have the anal fin far back and that they further agree with the catostomids in having the mouths inferior and more or less modified as a sucking organ, and in being bottom dwellers. He further expressed the opinion that the quoted distinction drawn by Hubbs and Lagler is "based on general relation between

the mode of living and proportional length of body parts," that the Gobioninae have occupied in Asia the niche appropriated by Catostomidae in North America, and that the strong resemblances between the two groups is an example of parallelism in evolution.

I quite agree. The posterior location of the anal fin, where the ventral contour rises toward the caudal fin, brings the anal fin out of contact with the bottom or allows its lower and often thickened, morphologically anterior border to rest on the bottom in line with the long flatish ventral surface. Furthermore, the longer abdomen in the more or less vegetarian or oozing bottom fishes makes room for a lengthening of the intestine that is associated with such diet, even without recourse to increased coiling.—CARL L. HUBBS, *Scripps Institution of Oceanography, University of California, La Jolla, California* (Contributions, New Series, No. 969).

**SECOND SPECIMEN OF THE BATHYPELAGIC FISH *PHOTOSTYLUS PYCNOPTERUS*.**—Among the unworked fishes in the United States National Museum is a small alepocephalid, identified as *Photostylus pycnopterus* Beebe, a species known hitherto only from the type, which was caught off Bermuda at a depth of 800 fathoms (Beebe, 1933, Zoologica, 13: 163, fig. 41; 1933, op. cit., 16: 83, fig. 23). The specimen reported here, USNM 148472, was taken by the ALBATROSS in August, 1885, at Station 2562, 39°15'30"N., 71°25'W., 1434 fathoms. It is 82.5 mm. in standard length, thus a little longer than the type (64 mm.) and it agrees with the type description in all characters except that the papillae of the larger fish are very small, difficult to see, and apparently not as numerous as on the type specimen. The fleshy, leaf-like organs on the intermandibular membrane are relatively large and the membrane itself is very thin and delicate. Long preservation has faded the specimen to a uniform pale yellowish brown, with the dark peritoneum visible through the body wall anteriorly. Preservation has also somewhat distorted the "predorsal fold or adipose fin" described in the type. Both the dorsal and ventral surfaces are somewhat softer in texture than the sides of the body and are obviously somewhat misshapen. One might hazard a guess that both of these surfaces had been rather flat in the living fish. The gillrakers are long, slender, smooth and close together.

Dorsal rays 14. Anal rays 18. Branchiostegal rays 6. The following measurements are in millimeters, followed in parentheses by percent of the standard length, which is 82.5 mm. Depth 10.5 (12.7). Head 14 (16.9). Snout ca. 5 (6.1). Eye 3

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(3.6). Interorbital width ca. 3 (3.6). Upper jaw 7.5 (9.1). Tip of snout to dorsal origin 63 (76.1); to anal origin 61.5 (74.5); to anus ca. 49 (60.0); and to ventral bases ca. 43 (52.1).—MARION GREY, Chicago Natural History Museum, Chicago 5, Illinois.

ANOTHER RECORD OF THE AGONID *BOTHRAGONUS SWANI* FROM CALIFORNIA.—The first report of the agonid fish *Bothragonus swani* from California was of a specimen collected at Shell Beach, Sonoma County, in 1949 (Haig, 1951, COPEIA (1): 102). This report summarized the other records of this little-known fish, all of which were from either British Columbia or northern Washington. The southernmost prior record station was La Push, Washington.

The second California specimen was collected at Trinidad, Humboldt County, California, at approximately 41°02'N and 124°08'W. It was caught on June 27, 1957 by John R. Sandretto and Bill G. Lewis, in a tide-pool, at a -1.5 tide. This area was searched during other minus tides but no additional specimens were found.

In life this fish was bright orange-red, with three brown hourglass markings on its sides (Fig. 1). These markings met on the dorsal midline to form saddles. A narrow brown band passed through and between the eyes. The paired and unpaired fins were brown with white markings. The body plates were not nearly as obvious as indicated by Clemens and Wilby (1946, Bull. Fish. Res. Bd. Canada, 68: 288, Fig. 210).

Measurements of this specimen are as follows: total length, 55.2 mm.; standard length, 46.3 mm.; head, 18.2 mm.; snout, 4.2 mm.; gape, 4.1 mm.; orbit, 3.0 mm.; interorbital, 4.3 mm.; maximum width of occipital pit, 6.9 mm.; width of head lateral to occipital pit, 17.0 mm. The fin-ray counts are D. V-5; A. 4. The other California specimen as reported by Haig had counts D. IV-4; A. 4; while those of the type specimen given by Steindachner and repeated by Jordan and Evermann (1898, Bull. U. S. Nat. Mus., 47 (2): 2086) were D. III-5; A. 5. Evidently the number of rays in the dorsal and anal fins is variable.

Due to the scarcity of specimens the typical habitat is unknown. This specimen was taken from a rocky tide-pool subject to much surge, even during a -1.5 tide. Among the associated animals in this pool were the solitary stony coral *Balanophyllia elegans* and the red sea cucumber *Cucumaria miniata*. The red color of the fish almost matched that of the living solitary stony coral. The water temperature was 53°F.

Some observations on the behavior of this fish in an aquarium led the author to believe that

it is typically a bottom form. In swimming it apparently used only the pectoral fins, which were moved slowly, somewhat butterfly-like. It spent most of the time on the bottom of the aquarium. Although it did some swimming, much of its activity took the form of "walking" on the aquarium bottom, during which it used only the pelvic fins. It frequently rested by propping itself on its pectorals, so that its body was not in contact with the bottom.

When touched this fish set up vibrations in the head region. This vibrating was not visible

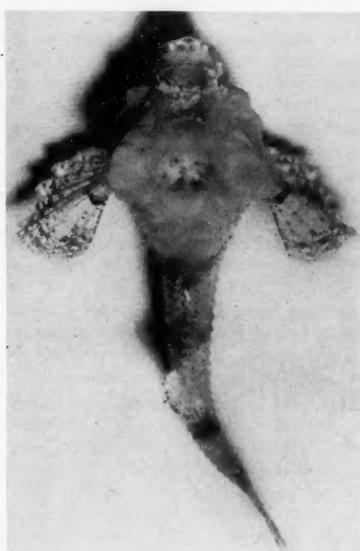


Fig. 1. *Bothragonus swani* from Trinidad Bay, Humboldt County, California. Total length 55.2 mm. This is the second record specimen of *B. swani* from California. (Photo from a kodachrome by J. Phegley.)

to the eye nor were the vibrations audible either in or out of the water; however, they could be distinctly felt by the fingers. These vibrations suggest the possibility that the strange occipital pit of this fish may function in either the production or reception of vibrations.—WARREN J. HOUCK, Humboldt State College, Arcata, California.

FERTILITY OF *F<sub>1</sub>* HYBRIDS BETWEEN THE PERCID FISHES, *ETHEOSTOMA SPECTABILE* AND *E. LEPIDUM*.—Although many *F<sub>1</sub>* hybrids have been reported in fishes (see Carl L. Hubbs, 1955, Syst. Zool., 4: 1-20) few reports on hybrid fertility are available. These reports include total infertility of trout × char hybrids (Alm, 1955, Ann. Rept. Inst. Freshwater Res.

Fish. Bd. Sweden, 36: 13-56) in many cyprinodont fishes (Öztan, 1954, Rev. Fac. Sci. Univ. Istanbul, 19: 245-80, pls. 1-7) and in intergeneric darter hybrids (Clark Hubbs and Strawn, 1957, Evolution, 11: 1-10). Reduced fertility in both sexes has been found in other salmonoid hybrids (Alm, *loc. cit.*) and in xiphophorin hybrids (Gordon, 1948, Spec. Publ. N.Y. Acad. Sci., 4: 216-68, pls. 84-96). Fertility apparently equal to that of controls has been reported for hybrids between *Molliesia latipinna* and *M. sphenocephala* (Carl L. Hubbs, 1955, *loc. cit.*), *Notropis lutrensis* and *N. venustus* (Clark Hubbs and Strawn, 1956, Evolution, 10: 341-44) and *Etheostoma lepidum* and *E. grahami* (Clark Hubbs and Strawn, 1957a, J.E.Z., 134: 33-62). The latter cross is between allopatric fishes whose differences may not merit specific ranking. Makino, *et al.* (1955, Ann. Zool. Jap. 28: 12-16, pl. 1) and Öztan (*loc. cit.*) reported cyprinid and cyprinodont hybrids respectively in which females are somewhat fertile and males sterile. Minamori (1956, Jap. Jour. Zool., 12: 89-104) had similar results with hybrids between two sympatric races of the striped spinous loach, *Cobitis taenia striata* Ikeda. Sexual differentiation in fertility of fish hybrids is not unexpected considering the predominant maleness of infertile hybrid sunfishes (Carl L. Hubbs and Hubbs, 1933, Pap. Mich. Acad. Sci. Arts, Letters, 31: 147-67) and the all female species *Molliesia formosa*, which is of apparent hybrid origin (Carl L. Hubbs and Hubbs, 1932, Science, 76: 628-30). Females of the hybrid combination here reported, *Etheostoma spectabile*  $\times$  *E. lepidum*, are fertile and the males are sterile.

The two darters have overlapping geographic ranges. *Etheostoma spectabile* occurs over most of the central United States. *Etheostoma lepidum* is endemic to the Edwards Plateau of central Texas. The two species occur together in parts of the Guadalupe and Colorado river systems. Their ecologic preferences differ in sympatric range. *Etheostoma spectabile* is most common on gravel riffles without much vegetation and *E. lepidum* abounds in vegetation, both in pools and riffles (Clark Hubbs, Kuehne, and Ball, 1953, Texas Jour. Sci., 5: 216-44). Outside the sympatric range both species are common in the other habitat. The two darters differ in primary spawning site: *E. spectabile* prefers gravel bottom (Winn, 1957, British Jour. Anim. Behavior, 5: 25-28, and Kirk Strawn, Personal Communication, 1956) and *E. lepidum* prefers filamentous algae (Clark Hubbs and Strawn, 1957b, Ecology, 38: 596-620).

The crosses have all been artificial following techniques described by Strawn and Hubbs (1956, Copeia: 114-16). Little success would be expected from natural hybridization as females

of both species have been isolated with males of the other and no fertilized eggs recovered.

Two hybrid stocks have been used for these experiments. Both have *E. spectabile* as female parent. One is between sympatric populations, from the Guadalupe River 2 miles west of Ingram, Kerr County, Texas, and the other between allopatric populations from within the sympatric ranges. The maternal parent, *E. spectabile*, was from the Colorado River at Austin and the paternal parent was from the San Saba River, 1 mile east of Fort McKavett, Texas. As no difference has been noted between the two stocks, they will be discussed together. The sex ratio approximates 1:1 in these two stocks as well as others of the same combination reared in this laboratory. Males are brilliantly colored and readily distinguished from females.

Females produce eggs regularly. Hatching percentages of these eggs (74 percent with *E. spectabile* sperm and 80 percent with *E. lepidum* sperm) are slightly lower than those of controls (90 percent for *E. spectabile*, 96 percent for *E. lepidum*, 79 percent for hybrids using *E. spectabile* eggs, and 89 percent for the reciprocal). Percentages to develop through larval stages (42 percent with *E. lepidum* sperm and 33 percent with *E. spectabile* sperm) are somewhat lower than the controls (63 percent for both *E. lepidum* and *E. spectabile*, 69 percent for *F*<sub>1</sub> hybrids using *E. lepidum* eggs and 54 percent for the reciprocal). Similar to *F*<sub>1</sub> hybrids viability of offspring does not appear to be correlated with degree of allopatry. Lowered viability of the ova from hybrids may be significant; however, laboratory held fish (all of the hybrids) often produce eggs with reduced viability and wild caught fish (most of the controls) seldom do. Clark Hubbs and Strawn (1957a, *loc. cit.*) suspected dietary deficiencies in the laboratory as the primary cause of the difference. The deficient item has been shown to be Vitamin A or a precursor.

Eggs from the hybrid stocks have also been successfully crossed with sperm of *Etheostoma radiosum*, *Hadropodus scierus*, and *Percina caprodes*. Similar to back crosses, those out crosses have low viability when compared with their controls, probably for the same reason.

Many attempts have been made to strip sperm from hybrid males. No visible milt has been observed. Occasionally wild males that do not have visible milt, especially *E. fonticola*, can be stripped successfully. Therefore, eggs have been exposed to males "stripped" in a manner similar to that of controls. Two of these used hybrid eggs and ten *E. spectabile* from Austin. None of these eggs hatched. As few other crosses based on simi-

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lar eggs failed to hatch, it is safe to assume male hybrid sterility.

My results with these hybrids correspond most closely with those of Öztan (*loc. cit.*) They differ in that all or nearly all of the females produce viable eggs and the number of functional females does not decrease with age.

This project is supported by NSF Grant 2214.  
—CLARK HUBBS, Department of Zoology, The University of Texas, Austin, Texas.

**SUBSTITUTE NAMES FOR NYSTACTES BÖHLKE AND LUCAYA BÖHLKE, PREOCCUPIED.**—The two papers in which these generic names were proposed were written, submitted and published together. Unfortunately, it appears that one critical step in their preparation was omitted, that of checking the new names against

Neave's *Nomenclator Zoologicus*. The names are both preoccupied.

*Nystactes* Böhlke (1957, Proc. Acad. Nat. Sci. Philadelphia, 109: 68) has been applied in birds by "...Gloger 1827, Notizen (Frerop), 16, 277-..." and in mammals by "...Kaup 1829, Skizz. Europ. Thierw., 108-..." (quotations from Neave 1940, 3: 368). *Nystactichthys* is here proposed as a substitute for *Nystactes* Böhlke, to take the same genotype (*halis*).

*Lucaya* Böhlke (1957, Proc. Acad. Nat. Sci. Philadelphia, 109: 83) is, according to Neave (1950, 5: 143), preoccupied by "*Lucaya* Chase 1939, Mem. Soc. cubana Hist. Nat., 13, 24.-Crust." *Lucayablennius* is here offered as a substitute for *Lucaya* Böhlke and takes the same genotype (*zingaro*).—JAMES E. BÖHLKE, Department of Ichthyology and Herpetology, Academy of Natural Sciences of Philadelphia, Philadelphia, Pennsylvania.

## REVIEWS AND COMMENTS

**VENOMS.** Edited by Eleanor E. Buckley and Nandor Porges. AAAS Symposium Volume no. 44, 1956: 480 pp., 113 illus. \$9.50.—The 61 papers included in this volume were presented at the first International Conference on Venoms during the AAAS Meetings in Berkeley, California in December, 1954. The papers cover a wide variety of topics, including general and specific considerations of venoms of both invertebrates and vertebrates. A useful index is included to aid the reader in locating specific items of interest. Herpetologists will find more of interest here than will the ichthyologists since about two-thirds of the papers discuss some aspect of snake venoms. However, there is material here to interest all zoologists, as well as biochemists, pharmacologists, physicians and veterinarians.

Aside from the general papers, of which there are four, only three deal specifically with toxins of fish. Two of these are on the stingray and its venom. Two papers discuss the gila monster and its venom. The studies on snake toxins vary from biochemical and pharmacological analyses to reports on the frequency and importance of snakebite in different areas. Perhaps the papers

dealing with the general aspects of snakebite and its treatment will prove of most interest to the herpetologists, but something of the varied contributions found here is indicated by the following topics selected solely to give a general idea of the contents of the volume. This brief list includes Minton's studies on pit viper venom in relation to phylogeny, Klauber's analysis of factors affecting the gravity of rattlesnake bites, Reid's report on bites by sea snakes, Morgan's work on the Australian taipan, Ghosh and Sarkar's analysis of the principles of snake venom, Criley's comments on a multivalent antivenin for crotalids, Boquet's evaluation of the effects of hyaluronidase on the therapeutic action of antivenins, and Shannon's criticism of the use of refrigeration in the treatment of snakebite. These, and the many other studies included, make this a valuable volume for everyone interested in the subject of animal venoms. This reviewer certainly hopes there will be many more symposia and subsequent volumes on this subject so that eventually we may get a sound knowledge of venoms, their action and control.—JAMES A. OLIVER, New York Zoological Society, New York.

VERTEBRATES OF THE UNITED STATES.  
By W. F. Blair, A. P. Blair, F. R. Cagle, P. Brodkorb, and G. A. Moore. McGraw-Hill Book Company, New York, 1956: viii + 819 pp., 416 text figures. \$12.00.—At long last the instructor of Vertebrate Systematics, Natural History and Ecology has a manual which can be used as a text, but at what a price! It seems that the publishing company has forgotten that text books must be bought by students and many of them with very limited funds. Despite this distinct disadvantage this book will fill an important gap in our textbook coverage.

The text is divided into six major sections, an Introduction, a section on Fishes, Amphibians, Reptiles, Birds and Mammals. There is an adequate Glossary and Index. Each section is demarcated by a single large illustration which occupies an entire page. The significance or the utility of these illustrations escapes me except that it adds to the cost of the book. The different sections have varying amounts of illustrations. The Birds and Mammals have the least number of illustrations, most of which are necessary for operation of the keys. The Reptile and Amphibian sections are plagued with many pointless, unclear or unnecessary figures. Two examples are those of *Anniella* (fig. 4-70) and *Lygosoma* (fig. 4-75) that add nothing to the text. The section on fishes is encumbered to a lesser degree. Even many of the excellent photographs and species figures in these sections are of doubtful value because they do not illustrate points in the key, nor do they contrast species in the keys. I can not see how the photograph of *Eumeces laticeps* aids in any manner the identification of the skinks or that it clearly indicates what a skink is. The authors should have decided to illustrate all the species of a complex or none. The diagrams of key characters are on a whole excellent except in places where they have been improperly reproduced as in fig. 6-19. The illustration of two species of *Crotaphytus* is comparative but is it really necessary for identifying two such easily distinguished species?

The volume is intended to include only the continental United States fauna, yet it does include marine mammals and birds but does not include turtles or fish. It could easily be understood why the marine fish were not included, but I can not understand why the turtles were left out. To those of us who are at coastal institutions, the lack of a section on coastal fishes will be considered a real handicap.

The Introduction is an excellent section, in which vertebrate characters, problems of nomenclature, problems of classification and distribution are discussed. In fact, I consider this sec-

tion too short and cursory, particularly when one considers that this is the Age of the New Systematics. It seems strange to me that in the short discussion of what a species is, types of interbreeding, allopatry, sympatry, etc. that the author did not take a single example from his own text. It is in this part of the text that the problems of vertebrate systematics could have been pointed out. The innumerable definitive decisions taken by the authors throughout the text hide their basic disagreements and the biological problems. A modern text calls attention to these problems even in a basic text. Furthermore, a comparison of taxonomic evaluations of the different sections does not reveal to me a uniformity of opinion. This alone would warrant an elaboration of this section.

Much of the vertebrate history is unnecessary since it is at best an extremely abbreviated version of sections in two excellent texts by Romer. Referral of the students to these texts would have been more than adequate and illustrations of pterodactyls could have been left out.

Inevitably, some errors will creep into a work of this size. It is not my intention to point these out, but merely to show where there is a difference in philosophy of presentation and judgement.

Under the family, Poeciliidae, the term gonopodium, which is the correct term for the fin modified as an intromittent organ, is never used. The term itself does appear in the glossary. Although there is a figure of a male and female *Gambusia*, there is no indication which is the male or the female, nor is there an indication of what the gonopodium might be. In the key to genera, the genus *Poeciliopsis* is distinguished by a complex set of characters, but no mention is made of its unique asymmetrical gonopodium.

In the section on Amphibia, there are problems presented by the arrangement as full species of *Bufo fowleri*, *B. woodhousei*, *B. terrestris*, *B. americanus*, etc. It seems to me that this arrangement requires further explanation than the simple statement that hybridization occurs. Perhaps this could have been considered in the introduction as an illustration of a type of speciation or other general principle. It is unfortunate that the manual does not agree with the Checklist for the proper generic name of the Eastern North American newts. If *Notophthalmus* was to be retained, then a note should have been added indicating its synonymy.

The bibliographies at the end of each section are not of equal quality but in general are very adequate. In some cases it would have been best to have a literature citation for a given systematic arrangement or for a key.

There is a valuable account of lists. My therefore that the accepted effect.—M. Queens C.

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There is no question that an interesting and valuable addition has been made to our text book lists. My chief objection lies in its cost and its therefore restricted utility as a textbook. I think that the authors should have made a more concerted effort to impress the company in this respect.—MAX K. HECHT, Department of Biology, Queens College, Flushing 67, New York.

**GUIDE TO THE FISHES OF NEW MEXICO.** By William J. Koster. Univ. New Mexico Press, 1957: vii + 116 pp., 104 illus. \$1.00—This well-printed booklet is designed for the angler and naturalist and will prove useful to the beginning student of fishes. Authoritatively written with a minimum of technical terms, it contains a concise summary about each of the 80 species reported from New Mexico, including observations on biology and distribution made by the author since 1938. There is no formal recognition of subspecies in this preliminary account of the state's fish fauna. The first 13 pages are devoted to general information covering such subjects as distribution, environmental requirements, reproduction, growth, conservation and identification. This is followed by a glossary of terms, counting methods, and an illustrated guide to families, with the bulk of the booklet taken up by species accounts. Additional readings are suggested and an adequate index is included. The line drawings, based on photographs, well portray the species but a closer approximation of number of fin-rays would have rendered them more useful. Clear distinction is not always made between native and introduced fishes.

This booklet is a bargain for its modest price and should serve its intended audience well.—ROBERT RUSH MILLER, Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

**THE PHYSIOLOGY OF THE PITUITARY GLAND OF FISHES.** By Grace E. Pickford and James W. Atz. New York Zoological Society, New York, 1957: 613 pp. \$6.00.—In the evolution of every field of science the early stages are characterized by a great preponderance of empiricism over unifying theory and by masses of conflicting data and interpretation stemming from uncertainties about what sorts of observations are critical. Comparative endocrinology is such a young field. Great progress has already been made, but there is much more still to be done than has been done. This book provides a detailed, critically analyzed picture of what has been done in a large and important part of this field.

The book is a comprehensive review of what had been learned about the varied functions and

interrelations of the pituitary gland in fishes up to June 1956, with an addendum covering the period to January 1957. It makes a significant contribution to comparative endocrinology by listing in one place a voluminous literature (there are over 1900 bibliographic citations), by putting in proper perspective many older observations, by extracting from the literature experimentally verified rationalizations for many apparent inconsistencies of long standing, and by clearly pointing out a great many profitable directions in which future research should proceed. The coverage of the literature is so complete that it can certainly fulfill the authors' aim of having it be a *vade mecum* for fisheries biologists and others who find themselves in places where they have limited or no access to good scientific libraries.

The treatment of each major subject begins with a brief and variably complete consideration of the situation as it is understood in vertebrates other than fishes. Pituitary-specific target organ relations in fishes are then described. Considerable material on the functions of the secretions of the target organs themselves (secondary pituitary effects) is included, also information on the interactions of various of the hormones. Major subjects covered are: general considerations (18 pages), hormones of the neurohypophysis (12 pages), chromatophore regulating hormones of the pituitary (28 pages), the adrenal and corticotropin (24 pages), the growth hormone (16 pages), the thyroid and thyrotropin (60 pages), miscellaneous and unclassified function of the pituitary (17 pages), and the relation of the pituitary to reproduction in fishes (92 pages). More detailed summaries of the data discussed in each section are presented in three text figures, 25 text tables and 54 supplementary tables (covering 115 pages). A brief appendix describes methods of hypophysectomy in fishes (3 pages). The bibliography is combined with a very carefully cross-referenced author index and is followed by a detailed subject index (by Atz).

The first two-thirds of the book were written by Pickford, the last third (reproduction) by Atz. Both authors have a generally clear style of writing. The value of their respective reviews is greatly enhanced by the fact that they are both ardent bibliophiles and have unearthed numerous Russian, Brazilian, Japanese and other foreign language papers which English-speaking workers might otherwise have remained unaware of. This is especially true for the Russian literature on thyroid-pituitary relations in sturgeons and for the Brazilian and Russian literature on pituitary treatment of fishes in pisciculture. The authors have also been industrious in obtaining

previously unpublished material from current workers in the field.

The places where the present reviewer felt that either author had perhaps overextended interpretation somewhat were few in number and limited in significance. The reviewer heartily seconds the repeated emphasis laid by both authors on three points: 1) the importance of adequately controlled experiments on hypophysectomized fish; 2) the continuing need for pure, chemically defined hormone preparations; and 3) the fact that, in inter-group experiments, chemical identity of the hormones being studied is not the only factor of importance—identity of tissue response must also be established before one can say that hormone functions are the same in different animals.

Despite the great efforts of its authors to unify the material and produce as much order as possible, this book is an outstanding example of an early stage in the evolution of a field. The overall impression created is neatly summarized by Pickford in a comment which seems more generally applicable than just to the situation regarding thyroid function in teleosts for which it is used. Pickford writes (p. 130): "The results are almost as conflicting as the literature is voluminous."

The book is lithoprinted in a clear format. Typographical errors are few and small (18 noted in 270 pages of text). The binding is paper, but seems quite sturdy. Finally, the price is reasonable.—MALCOLM S. GORDON, 1305 53rd Street, Brooklyn, New York.

**THE PHYSIOLOGY OF FISHES. VOLUME 1—METABOLISM.** Edited by Margaret E. Brown. Academic Press Inc., New York, 1957: xiv + 447 pp. \$12.00.—This first of two volumes comprises ten chapters, most of which are more or less concerned with the metabolic aspects of the topics indicated by their titles: Ch. I, *Respiration*, part 1, *The aquatic respiration of fish* by F. E. J. Fry and part 2, *Air breathing* by G. S. Carter; Ch. II, *The cardiovascular system* by J. C. Mott; Ch. III, *The alimentary canal and digestion* by E. J. W. Barrington; Ch. IV, *Excretion and osmoregulation* by V. S. Black; Ch. V, *The skin and scales* by J. Van Oosten; Ch. VI, *Endocrine organs and Ch. VII, The gonads and reproduction* by W. S. Hoar; Ch. VIII, *Early development and hatching* by S. Smith; Ch. IX, *Experimental studies on growth* by M. E. Brown; Ch. X, *The biochemical composition of fish* by R. M. Love. Indices are provided for authors' names appearing in the text, as well as to subject matter. The contents of volume 2, to be titled *Behavior*, are given on page xiii.

As to be expected from a compilation of this nature, the authors vary in the approach and intensity of coverage of their subject matter. Chapters V and X could have been judiciously condensed since in their present state too little physiology is communicated to the reader for the space consumed. The editor's concept of what constitutes physiology is broad. To be sure, gradations exist with neighboring disciplines but in spite of this, static determinations of chemical composition (Ch. X) are more properly considered to be morphology. It is more difficult to fit in descriptions of the histology and morphology of skin and scales (Ch. V), and how the latter are used in classification and life history studies, with the functional viewpoint.

Considering the space wasted on irrelevant material in chapters V and X, it is disappointing that several deserving topics were omitted from the tables of contents of both volumes. For example, there is a respectable amount of literature on locomotion in fishes, and work has been done on the physiology of muscle, bone, and cartilage. The absence of a discourse on muscle physiology is made more apparent by the advertised inclusion of a section on electric organs in volume 2.

Some of the material in the text has been included without prior critical evaluation by the authors. One may question several of the statements made in the book, such as Brown's suggestion that some fishes may be immortal (p. 369). This is a thesis that cannot yet be proved, and Brown does not specify which species are thought to be immortal. Hoar (p. 290) states that functional hermaphrodites are normal only in the Sparidae and Serranidae; this is based solely upon histological evidence, and has not been experimentally verified. Van Oosten (p. 218) and Brown (pp. 380-381) suggest that the skin of fish may absorb nutrients dissolved in the surrounding water; the evidence in favor of this can be interpreted in other ways, but the hypothesis is attractive and if true may have some bearing on the physiology of larval development.

Minor criticisms follow. The nomenclature could have been made more uniform in the text instead of listing synonyms in the index. In the lists of references which follow each article, the bulk of the citations are in English; some reference is made to the French, German and Italian literature but other languages are poorly represented. The method of listing references is not uniform; Carter's citations do not include titles and Van Oosten's article does not give any literature citations other than a "selected bibliography", thereby losing much of its value as a review; but the remaining articles are satisfactorily documented.

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Taken as a whole, the articles are well-written and in most cases bring the reader "up to date" (to 1955, occasionally to 1956) in the rapidly expanding literature of fish physiology. Space limitations prohibit a thorough review of the literature; each chapter is based upon selected references. Brown indicates in the editorial preface (p. vii) this is the most comprehensive work on the subject in English. It is hoped that if a revised edition is to be considered, it will be more comprehensive. The value of this first volume to the research worker lies in its bringing together of some of the literature. Its use as a textbook for advanced undergraduate and beginning graduate courses in ichthyology and fishery biology would be recommended but the cost for the two volumes will be \$24.50 and it is doubtful whether many people other than those in charge of the courses will be able to afford this.—VLADIMIR WALTERS, *American Museum of Natural History, New York.*

**VIDA DE BATRACIOS Y REPTILES SUDAMERICANOS.** By Marcos A. Freiberg. Cesarini Hnos., Sarmiento 3231, Buenos Aires. 1954. 192 pp., 44 pls., 6 figs., 1955.—Dr. Marcos A. Freiberg is well-known to North American herpetologists for his scientific studies on Argentine amphibians and reptiles. The present work is a popular account of the lives and habits of amphibians and reptiles in general, with primary emphasis on South American species. While the title indicates the book covers the herpetofauna of South America, only a small number of forms are mentioned by name and these are mostly Argentine species.

Four of the fourteen chapters are devoted to the fossil history of amphibians and to the surviving orders, with three of the chapters discussing frogs. The remainder of the book is devoted to the reptiles and covers such topics as fossil and living reptiles, harmless snakes and mimicry, false coral snakes and true coral snakes, venomous pit vipers, snake venoms and treatment of snakebite, superstitions and legends about snakes, lizards, turtles and crocodilians. The book presents a simplified but modern treatment of all of these topics and contains few misstatements. Dr. Freiberg has condensed a surprising amount of information in his brief accounts. Several of the scientific names are not those currently used by most taxonomists, but the North American herpetologists will find the book of interest for its observations and photographs of a number of relatively little known species from southern South America.—JAMES A. OLIVER, *New York Zoological Society, New York.*

**TERRARIENKUNDE. 2. TEIL LURCHE.** By Wilhelm Klingelhöffer. Second, completely revised edition issued by Christoph Scherpner. Alfred Kernen Verlag, Stuttgart. 1956: 236 pp., 5 col. pls., 184 figs. Paper cover. Price approx. \$6.30.—This is the second volume of the revised edition of Klingelhöffer's terrarium handbook, but the subtitle "Amphibia" is a misnomer since only salamanders and frogs are covered. This is, however, one of the few critical remarks that may be made. Far from serving only as a guide to the keeping of animals in a terrarium this volume contains an amazing amount of life history information. The very overemphasis of the German literature is of advantage to the American reader as it provides him with a guide to many short papers unfortunately of limited distribution in this country.

After a very brief section of general remarks (6 pp.), the remainder of the volume is divided into discussions of salamanders (78 pp.) and frogs (146 pp.). For each section there is first a brief chapter on the arrangement of terraria, followed by detailed discussions of individual forms. The section on frogs also contains a special chapter on breeding methods and habits. Salamanders are covered by continents, the frogs by major groups. Emphasis has been on the forms available to European fanciers in the past, and these certainly form a respectable selection. The few mistakes in listing the range of exotic species are certainly unimportant to the main purpose of this volume. The photographs range from good to excellent. All of them depict live animals. Many of these are illustrated in their characteristic position, many while engaging in some activity.—CARL GANS, *Department of Biology, University of Florida, Gainesville, Florida.*

**REPTILES OF ISRAEL.** By Al. Barash and J. H. Hoolien. Hakibutz Hameuchad Publishing House, Tel-Aviv, 1956: 179 pp., 83 figs., 1 map. \$3.95.—This popular guide in modern Hebrew to the 85 species of reptiles found in Israel is divided into two portions, a generalized introductory biology of reptiles and an annotated key. The first section includes a discussion of the morphology and biology of the Class and each of the Orders found in the area under discussion. In the second section, an annotated key, there is a brief description, short distributional, habitat and habit account under each species (at the point in the key where the species is identified). There is one map showing the distribution of the poisonous snakes of the old British mandate of Palestine. This work is profusely illustrated although many of the figures are copies of figures from the classic works of

herpetology. There are some excellent original drawings and a few beautiful photographs. There is also a very short bibliography.

The Reptiles of Israel is limited in its utility to herpetologists by the nature of the language in which it is printed. To the student who can read Hebrew it is a useful guide to the reptiles of this very important zoogeographic area. The keys should be useful in the regions adjacent to Israel. The book unfortunately lacks adequate maps and as a result is of limited value to the foreigner. It is probable that for such a small country the very short distributional descriptions are adequate for the average Israeli layman. Further ecological notations and life history data for each species would have made this work more valuable to the biologist, but it must be remembered that this guide is oriented for use as a popular guide. To the layman this guide and key will serve as an excellent introduction to a portion of the fauna of his country.—MAX K. HECHT, Department of Biology, Queens College, Flushing 67, N. Y.

**REPTILES.** By Angus d'A. Bellairs. Rinehart & Co., New York. 1957: 195 pp, 12 figs. \$1.50.—This small book, intended as a résumé of the "evolution, structure, function and life-history of reptiles, both living and extinct" is a rather uneven but highly interesting piece of work.

There are two introductory chapters, one on the general characters and the other on the anatomical and functional features of the class as a whole. The anatomical approach is broad and prepares the reader for more detailed accounts in successive chapters; special emphasis is given to the skeleton, sense organs and reproduction. On the physiological side thermal requirements and regulation are given a prominent place.

The remaining chapters but the last deal with individual orders or groups of orders, living and extinct.

The paleontological items are ably written, but add little to a field where, among others, Romer and Colbert have made significant contributions to the semi-popular treatment of scientific data.

Among the Recent groups, turtles and crocodilians are shortly dealt with, seemingly with little enthusiasm. The real meat of the book, which makes it a remarkable one, is the treatment of the Squamata, anatomical, systematic and bionomic.

Bellairs is one of the foremost reptilian anatomists of our day, and his application of anatomical concepts to the systematics of the group has received well deserved appreciation. Writing very synthetically, and consequently somewhat dog-

matically, he gives a cogent, clear and logical view of the whole of the group and one which is a good starting point for the beginner or general zoologist and an excellent resting-station for the professional herpetologist.

The bibliography, short but to the point, is apparently aimed at the general public, and for the purpose very adequate.

The illustrations are very poor. The sketches of animals are so reduced as to lose any meaning. The anatomical drawings suffer from the same evil, and are placed so uncomfortably far from the pertinent points of the text as to irritate the reader.

All in all, this book is normal at its worst and excellent at its best. The reviewer has found it pleasant reading and has already had the opportunity of using it as reference, and wholeheartedly recommends it to herpetologists and interested persons.—P. E. VANZOLINI, Departamento de Zoologia, São Paulo, Brazil.

**EUROPAS GIFT SCHLANGEN** By Bruno Wittmann. Hippolyt-Verlag, Vienna; St. Polten, Munich, 1954: 189 pp., 36 pls. (15 phot., 6 line cuts, 15 col.). \$4.50.—This is a very much popularized treatment of the poisonous snakes of Europe. The first third of the volume contains a series of vignettes describing "pictures from [the] life" of snakes, and upon this follows a discussion of the opisthoglyph and solenoglyph forms by species. Finally there is a brief section on snake poisons and on the treatment of snake bite. The numerous photographs give a good presentation of the pattern details they are supposed to depict; the colored plates cannot be judged as this reviewer is unfamiliar with live specimens of the forms in question.

The illustrations and discussions of the pattern variation will unfortunately be the only worthwhile portion of the book for most American readers, as the author's views on habits are hardly enlightening. Even if the reader's command of the German equivalent of purple prose is adequate, he will find little of real use. This is probably due to the fact that the author has restricted his sources to back issues of one popular magazine (Kosmos), plus the 1936 Beringwerk report (Schlossberger, *et al.*) and six other volumes. Wiedemann is often cited without specific source; the more recent studies on ophidian habits are ignored. There are many clearly erroneous statements (*i.e.* the purpose of the crotaline pits is unclear; shedding is coordinated in snakes, all specimens in a population shedding at once; alcohol does not neutralize snake venom, etc.). Many other items in the vignettes are misleading at best, and permit faulty conclusion that

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**NORMAL TABLE OF XENOPUS LAEVIS (DAUDIN).** Edited by P. D. Nieuwkoop and J. Faber. North-Holland Publishing Co., Amsterdam, 1956: 243 pp., 10 pls. \$6.00.—This is an excellent short but remarkably complete summary of the embryology of this African frog that has become a laboratory animal. Though initiated and edited at the Hubrecht Laboratory of Utrecht, Holland, it has involved the collaboration of 20 distinguished scientists on three continents. A short chapter by H. W. Parker recounts the taxonomic history and current classification of the genus. Another chapter is a brief discussion of the ecology of *X. laevis*, normal and induced spawning and the rearing of tadpoles. The remaining chapters concisely describe first early embryology, then organogenesis and finally list and characterize the stages of normal development. Each stage or organ system is treated by an expert. There is a very useful 44 page bibliography of Anuran development arranged by special topics.

**DIE REPTILIEN UND AMPHIBIEN MIT-TELEUROPAS.** By Richard Sternfeld, 2nd edition reworked by Gerolf Steiner. Quelle & Meyer, Heidelberg, 1952: 94 pp., 30 col. pls., 22 figs. Approx. \$2.00.—This is the second edition of this field guide to the central European herpetofauna obviously written for beginners in the field and designed to attract amateur naturalists to herpetology. It should successfully serve this purpose. The text which has been expanded slightly and brought up-to-date is both simple and brief. A short sketch deals with each species, its recognition, habits and methods of keeping it in captivity. There are keys to all forms mentioned and adequate introductions to classes and (sub)orders. The colored plates have not been changed from the earlier edition and range from good to excellent, though several of the added text drawings leave something to be desired.

**STRANGE WONDERS OF THE SEA.** Translated and adapted from J. Forest's "Beautés du fond des mers" by H. G. Vevers. Hanover House, Garden City, New York, 1957: 102 pp. \$4.95.—The title may deter some prospective purchasers, but a book should not be judged by its cover.

The buyer gets more than his money's worth in color and black-and-white photographs alone. There are 35 color photographs, seven occupying

a page apiece. The colors have reproduced well but in their zeal to bleed the plates the publishers introduced some inadvertent amputations; *Pterois volitans* has lost the tips of its upper caudal rays, *Balistes aculeatus* lacks the tips of the lower caudal rays, and some of the mollusks and crustaceans have suffered similar indignities. Black-and-white photographs total over 90, and the overall quality of their reproduction is very high. Plate 55, a figure of *Limulus*, is a photograph of a cast exoskeleton. Scattered at irregular intervals through the book are segments of text, each from a few lines to a page and a half in length; the writing is well done. The book is purported to be "...an essay in excitement; an imaginative document which presents the astonishing variety of the animal life of the sea...". To this end the attempt is successful.

**KRANKHEITEN DER AQUARIENFISCHE.** By H.-H. Reichenbach-Klinke. Alfred Kernen Verlag, Stuttgart, 1957. 215 pp.—Several publications dealing with diseases of aquarium fishes have appeared in recent years. Readers who feel more at home with English than with other languages would prefer van Duijn's book, an English translation of which appeared in 1956 (see COPEIA 1956, p. 134). The present book is better illustrated, and is an overall more scholarly work.

**THE SCIENCE OF AQUATIC RESOURCES,** Suisan Shigengaku. By Dr. Itsuo Kubo and Tomokichi Yoshihara. 345 + 12 pp. Kyoritsu Shuppan Co., Tokyo, 1957.—A new textbook for the study of populations of aquatic organisms from the fishery point of view, written by two professors of the Tokyo University of Fisheries. The book, which is nicely printed and illustrated, summarizes a tremendous amount of material from many sources, as evidenced by the fact that 47 pages are taken up with the list of works cited, at least half of them non-Japanese publications. The 17 chapters deal with such subjects as stocks and their definition, age determination, growth of individuals and of populations, survival phenomena, methods of estimating populations, analysis of fluctuations in populations, overfishing and the optimum catch, propagation and protection, tagging, preservation of specimens, and methods of measuring animals. The book appears to be not only an excellent text for fisheries students but also a convenient reference to the major concepts and methods of fish population study. It is entirely in Japanese.

## EDITORIAL NOTES AND NEWS

### Awards

#### Western Division

Herpetology. 1st prize: Miss Velma J. Vance, Department of Zoology, University of California, Los Angeles 24, California. 2nd prize: James P. Mackey, Department of Biology, University of Oregon, Eugene, Oregon.

Ichthyology. 1st prize: Jac C. Quast, Department of Zoology, University of California, Los Angeles 24, California. 2nd prize divided between: Warren C. Freihofer, Natural History Museum, Stanford University, Stanford, California, George W. Barlow, Department of Zoology, University of California, Los Angeles, 24, California.

### K. P. Schmidt Memorial Issue of Copeia

A issue of COPEIA will be dedicated as a memorial issue to KARL P. SCHMIDT. Members desiring to contribute should direct their checks to the treasurer, DR. JAMES E. BÖHLKE, Academy of Natural Sciences, 19th and Parkway, Philadelphia 3, Pennsylvania.

### Memorial Fund for

K. P. Schmidt SCHMIDT have inquired about plans for a memorial in his honor. A committee, after debating several proposals, decided that a fund to aid naturalists desiring to use the research facilities provided by a large natural history museum most closely reflects the character and life-long interest of KARL P. SCHMIDT. Such a fund, to be known as the KARL P. SCHMIDT FUND, is being set up. Income from the fund will be distributed in the form of grants-in-aid. For purely administrative reasons, grants will be limited to work at the Chicago Natural History Museum. Grants will be administered by a self-perpetuating committee drawn from the staff of The Chicago Natural History Museum and the several universities in the Chicago area.

A letter explaining the plan in detail and soliciting contributions to the Fund will be mailed shortly to members of the American Society of Ichthyologists and Herpetologists. All contributions to the Fund should be addressed to: The Karl P. Schmidt Fund, Chicago Natural History Museum, Chicago 5, Illinois. Checks should be made payable to "The Karl P. Schmidt Fund."

### Zoological Nomenclature

The following awards were made at the meeting of the Western Division:

rangements have been made for the immediate publication in book-form of the first installment of each of the "Official Lists" of valid zoological names and of the corresponding "Official Indexes" of rejected and invalid names, together with the first installments of the "Official Lists" of works approved as available for zoological nomenclature and of the "Official Index" of rejected and invalid works. The categories of names covered by these "Lists" and "Indexes" range from specific names to ordinal names. The total number of entries contained in the installments now to be published amounts to about five thousand.

The first of these "Lists," that relating to generic names, was established by the Ninth International Congress of Zoology, Monaco, 1913, while the most recent were brought into existence by the Fourteenth Congress at Copenhagen in 1953. The entries made on these "Lists" and "Indexes" have been promulgated from time to time by the International Commission on Zoological Nomenclature in individual "Opinions" and "Directions" but owing to the large number of documents involved it has become increasingly difficult for specialists to ascertain what names have so far been registered. This difficulty will disappear on the publication of the installments now in press, each of which will be supplied with a full alphabetical index and also with alphabetical indexes arranged by major groups. The groups so selected will normally be Classes but in the case of large Classes containing well-recognized Orders, these supplementary indexes will be on an ordinal basis.

Inquiries should be addressed to: Publications Office, International Trust for Zoological Nomenclature, 41 Queen's Gate, London S.W. 7.

### News Notes

DR. FERNANDO DE BUEN, honorary foreign member, has resigned his position as Asesor Técnico of the Dirección General de Pesca e Industrias Conexas de México to take up work with the Centro de Investigaciones Zoológicas, Ave. José P. Alessandri 774, Casilla 10.135, Santiago, Chile.

DR. ROBERT W. HARRINGTON, JR. gave an invited paper "Sexual Photoperiodicity in Fishes with Respect to the Phases of the Annual Reproductive Cycle" at the International Symposium on Photobiology, Gatlinburg, Tennessee, Oct. 29 to Nov. 2, 1957. The papers of this symposium, supported by the National Research Council and

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the National Science Foundation, will be published in book form.

DR. VERNON C. APPLEGATE, (Bureau of Commercial Fisheries, Hammond Bay Fishery Laboratory, Rogers City, Michigan) offers for sale a run of *Copeia* from 1945 through 1955 for \$50.00, postage prepaid.

The following statement was omitted from V. G. SPRINGER "A New Genus and Species of Elopidae Fish (*Lamnospodus transversus*) from the Upper Cretaceous of Texas" *Copeia*, 1957(2). "Dr. David Dunkle, U. S. National Museum, discussed the problem with me and gave advice".

At the Stanford Meeting of the AIBS, DR. ARNOLD GROBMAN was elected a member of the Executive Committee for a three-year term, beginning January 1, 1958.

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1. A manuscript should present new knowledge or interpretation of the biology of fishes, amphibians or reptiles. Submission of the manuscript involves the assumption that no similar paper has been, or will be, published elsewhere.
2. The editorial board will discourage in general the following: a. tables that can be presented adequately in paragraph form; b. illustrations that do not supplement the text; c. separate notes on small range extensions; d. anatomical papers that do not contribute to knowledge of interrelationships, evolution, or physiological or ecological adaptations.
3. The manuscript should be prepared in clear, precise English. Every word, phrase and sentence should contribute to the subject. *Copeia* is read by biologists in many foreign countries. Technical neologisms and jargon should not be used; when unavoidable, such terms must be defined.
4. The author is responsible for putting his original manuscript in *final form* for publication. The cost of galley changes, other than corrections of printers' errors, will be charged to the author.
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8. The author is responsible for statements, conclusions, and methods of presenting their material. These may or may not conform to the views of the editorial board.
9. Manuscript must be typed double spaced on bond paper. The original, not a carbon, must be submitted. Extra copies will expedite review.
10. The author should examine recent issues of the journal in order to decide whether his manuscript should be prepared as a note or a major paper and to determine correct format. In general, manuscripts of less than 6 pages (elite type, double spaced) should be prepared as notes. The editorial board reserves the decision on manner of publication.
11. The following material should be on separate pages: a. legends for figures and plates; b. footnotes in the text; c. tables; d. literature cited.
12. Footnotes to a table should be typed beneath the table and numbered separately for each table (not numbered in sequence with footnotes in the text).
13. The title should be short and suggest the major contributions of the paper, but, when these items are significant, should briefly indicate the animal group and the region.
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- Tables shall be designed for publication in single column width when possible; otherwise for double column.
- Extensive, detailed tables of original data shall be avoided. Such tables of interest to a relatively few readers may be submitted to the editor for deposition with the American Documentation Institute. This deposition may be reported in the published article and the data will be available from the American Documentation Institute in photostat or microfilm form to those requesting it.
- The style for citing literature is that used in the last issue of *Copeia*. Insure uniform, complete citations; the exact wording of the titles should be given. Papers with incomplete references will not be accepted. References to "unpublished abstracts," "doctoral theses," "personal communications," etc., may be indicated in the paper but not included in "Literature Cited." References to papers accepted for publication, but that have not appeared, should be cited like other references with the name of the journal followed by the words "in press," "Major papers" and "Notes" must conform with the method of literature citation used in the respective section of the journal.
- Literature cited is to be listed in alphabetical order. The proper order may be decided on the basis of the first capitalized letter of the last name and then the alphabetical sequence of succeeding letters. Names with a prefix (von, de, du, la) are grouped according to the first capitalized part. Thus, von Hofsten under H, La Motte under L, de Beer under B.
- At least in the first use in each paragraph specific and subspecific names should usually be preceded by the generic portion of the name, or by the abbreviation for same where desirable. No specific or subspecific name is to appear alone in the title of a paper (Example: A new frog of the *pipliens* group from México). Do not begin a sentence with a specific or subspecific name.
- The museum abbreviations UMMZ, USNM, MCZ, SU, CNHM, UMNH, etc., are to be written as capitals without punctuation. They should be followed by the museum number (or numbers) as follows: USNM 136429; MCZ 4319.21. Do not abbreviate number to No. when the reference is to number of individuals; when it is used to designate a specimen number, abbreviate to No., e.g. "Specimen No. 5."
- The following words are to be written without hyphens: cooperation, freshwater (for the adjective, as freshwater pond; but use fresh water for the noun), percent, saltwater (the adjective; but brackish-water is to be written with a hyphen when used as an adjective), gillraker(s), gillnet, dipnet, trapnet.
- Always use figures for dates, temperatures, and measurements of other physical quantities which, as continuous variables, are measured in decimal fractions (25, 1 F, 7.1 inches, 1.54 pounds, etc.). The problem of numbers is largely concerned with non-continuous (discrete) variables that are enumerated by counting (number of specimens, number of scales, etc.). A general rule: write out numbers up thru ten (one, five, ten), but use figures for eleven and above (11, 20, 201, etc.). Use commas in high numbers (1,205,220,000) except in a few special cases such as museum specimen numbers (USNM 12056, etc.). In articles where perhaps only one or two (or very few) figures are given in the text, a single reference to 11 specimens may be written out "eleven" (but do not apply this to numbers over 100). In text containing a great many numerical data (either an entire article, or certain individual paragraphs of a long article), use figures for all numerical data. Occasionally certain paragraphs of text will be largely a listing of taxonomic data with number of specimens, and here all numbers of specimens may be written out and all morphological data may be given as figures, to differentiate between the two. Example "The distribution of scale counts among these specimens was: One specimen had 9 scales, ten had 10, thirty had 11, twenty-

five had 12, etc." or, "Scales 9 (in 1 specimen), 10 (10), 11 (30), 25 (12).

34. New scientific names, are to be followed by one of the following abbreviations: gen. nov., sp. nov., or subsp. nov.

35. The spelling of geographic names, is to be determined by reference to the latest edition of Webster's Geographical Dictionary.

36. For directions and time of day, small capitals and no periods are to be used: NE, SW, AM, PM, 12 N (for noon), 12 PM (for midnight).

37. Page references in the Literature Cited section and in the text should be written: 72-8, 335-8 (not 335-338), 406-19, 499-501.

38. Scientific names are to be treated properly as in the nominative singular. Examples: *Drosophila* is (not are) common in the Southwest; Measurements of twenty specimens of *Petromyzon* (not twenty *Petromyzon*) are given in Table I.

39. Common names are not to be capitalized in text use. The first letter may be capitalized when names are used as formal center headings (e.g., under the scientific name of a new species) or when presented in a formal list of names. Common names shall conform with the official lists published by the Committees of Common Names of the ASIH unless the author provides explicit reasons for his exceptions.

40. The general rule in forming the plurals of most animal names is to use the normal singular form if several individuals of the same species is involved, but to add an "s" if more than one species is considered. Examples: fish, fishes; salmon, salmons.

41. In referring to the published work of another author, always use the past tense.

42. The citation of the page number is recommended when a specific species, sentence, item of thought or debate, etc. is referred to. Example: "Jones (1939: 214) reported that this species . . .".

43. Such words as river, basin, system, county, when part of a geographic term, are capitalized in the plural form. Thus: "The fishes of the Red River System," but "The amphibian fauna of the Kiamichi and Appalachicola rivers."

44. Names of states of the United States, excepting Idaho, Iowa, Ohio, and Utah, are to be abbreviated in citations to publications according to the accepted abbreviations. The abbreviation adopted is Pa. for Pennsylvania, Ore. for Oregon, and Neb. for Nebraska.

45. Names of foreign countries are not to be abbreviated: Thus Canada, México, etc., are to be written out in citations, e.g.: Jour. Fish. Res. Bd. Canada. All city names are to be written out.

46. Certain journals, particularly those with single, monosyllabic or short titles or those that are difficult or impractical to abbreviate, are not to be abbreviated. Examples are: Nature, Science, Zoologica, Herpetologica, Isis, Sinensis, Ecology (but Jour. Ecol. for Journal of Ecology), Genetics, Turtox News, Evolution, Auk, Behaviour, Endeavour, Torreia, Biometrika, Condor, Forest and Stream, Heredity (but Jour. Hered. for Journal of Heredity).

47. Abbreviations in text: Twp. (Township), Hwy. (highway), T4N, R5E, Sec. 5, long., lat., cc., m., cm., mm., ppm., F. (Fahrenheit), C. (centigrade), in., ft., yd., yds., Co. (County), I., and Is. (Singular and plural for Island), 20°F. (degrees), g. (gram), fath. (fathom, -s).

48. Every writer should have available a Webster's Unabridged New International Dictionary and the following references used by the editors in evaluating and correcting manuscripts. Fowler, H. W. 1926. A Dictionary of Modern English Usage. Oxford University Press London. Evans, Bergen and Cornelius Evans. 1957. A Dictionary of Contemporary American Usage. Random House, New York.

49. The books "A Manual of Style", The University of Chicago Press and "Words into Type," Appleton-Century Crofts, Inc., New York, provide detailed information on style.

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